Vol. 6 NOVEMBER, 1923 No. 11

Journal

of the

American Ceramic Society

Ceramic Abstracts and the Bulletin

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

CONTENTS

Original Papers:

Further Studies of Porcelain Glazes Maturing at High Temperatures—Twells, Jr. ... 1113
Temperature Control of Dressler Tunnel Kiln—Harrison ... 1128
Note on the Heat Distribution in Updraft Kilns—Bleininger ... 1134
Ophthalmic Glass—A New American Product—Montgomery ... 1140
Effect of Various Sizes of Grog Particles on Clay Pots—Williams ... 1148
An Investigation Concerning the Influence of the Alkalies and Alkaline Earths on the Fusion Temperatures of the Different Types of Refractory Clays—Watts ... 1150
The Flint Clay Situation in Ohio—Stout ... 1153
Geology of the Baraboo Ganister Deposits—Hotchkiss ... 1160
Refractory Clays of the Alberhill, California Deposits—Burchfiel ... 1167
Refractories Colloquium—Consumers' Problems:
Refractory Requirements for Oil Refining—Wikoff ... 1176
Metallurgical Requirements for Refractories in the Electrothermic Metallurgy of Zinc—O'Harra ... 1180
Outline of Refractory Requirements for the Iron and Steel Industry—Davis ... 1183
Metallurgical Requirements of Refractories in Copper Smelting and Refining—Pyne ... 1188
Refractories for Stokers—Bouton ... 1190
The Value of Uniform Fire Brick from the Standpoint of the Consumer—Harrington ... 1193
Refractories for Flat Arches—Harlow ... 1195
Effects of Accelerators and Retarders on Calcined Gypsum—Welch ... 1197

Ceramic Abstracts ... 235

The Bulletin:

Editorial ... 343
Activities of the Society ... 345
Notes and News ... 351

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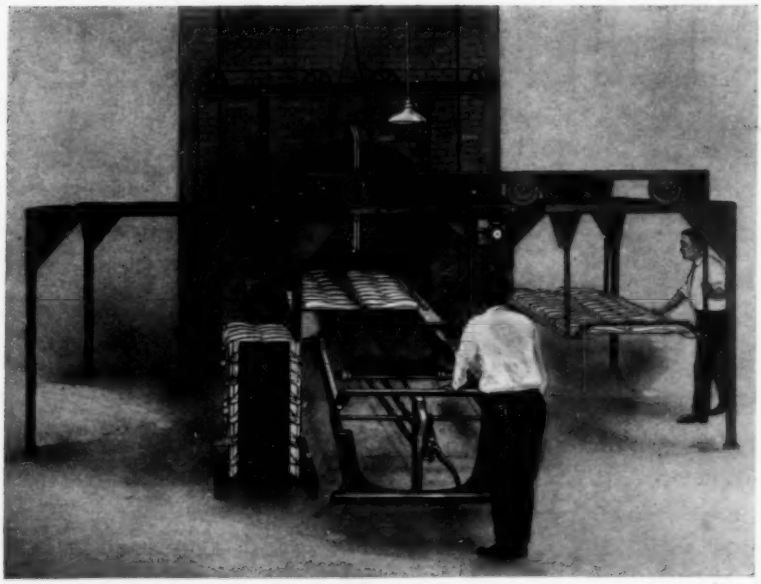

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A monthly Journal devoted to the arts and sciences related to the silicate industries.

Publication Office: 211 Church St., Easton, Pa.
Editorial and Advertising Offices: Lord Hall, O. S. U., Columbus, Ohio.
Committee on Publications: F. K. Pence, Chairman; A. W. Kimes, F. H. Rhead, W. E. Dornbach, Ross C. Purdy.
Editor: Ross C. Purdy; **Assistant Editor:** Emily C. Van Schoick; **Associate Editors:** L. E. Barringer, E. W. Tillotson, Roy Horning, R. R. Danielson, A. F. Greaves-Walker F. H. Rhead, H. Ries, R. L. Clare.

Entered as second-class matter July 15, 1918, at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 16, 1918.

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Eight dollars a year Single numbers, 75 cents
(Foreign postage 50 cents additional)

Vol. 6 **November, 1923** **No. 11**

ORIGINAL PAPERS

FURTHER STUDIES OF PORCELAIN GLAZES MATURING AT HIGH TEMPERATURES[1]

By Robert Twells, Jr.[2]

ABSTRACT

The investigation covers three fields of glazes: Series A contains 21 glazes with variations in composition as shown in the formula $\left.\begin{matrix}0.3\ K_2O \\ 0.2\ \text{to}\ 0.7\ CaO \\ 0.0\ \text{to}\ 0.5\ BaO \\ 0.0\ \text{to}\ 0.5\ MgO\end{matrix}\right\}\ 1.3\ Al_2O_3(11.0SiO_2)$.

Series B contains 10 glazes, each having the formula $\left.\begin{matrix}0.3\ K_2O \\ 0.7\ CaO\end{matrix}\right\}\ 1.3\ Al_2O_3(11.0SiO_2)$, but having their clay content varying triaxially between Florida kaolin, North Carolina kaolin, and Kentucky ball clay No. 4. Series C contains 20 glazes with variations in composition as shown in the formula $\left.\begin{matrix}0.2\ K_2O \\ 0.8\ CaO\end{matrix}\right\}\ 0.8\ \text{to}\ 1.6\ Al_2O_3\ (8.0\ \text{to}\ 14.0\ SiO_2)$.

The method of experimentation consists of grinding the corner glazes of each series wet, for 18 hours, cross blending the corner glazes to produce the intermediate glazes, applying the glazes by dipping to green porcelain discs, and firing them in commercial periodic and tunnel kilns to temperatures between cone $16^1/_2$ and cone 19 flat. The glazes were examined with the naked eye and a 10 X pocket lens.

The triaxial replacement of CaO by MgO and BaO, as tested, makes practically no change in the appearance of the glazes. With the pocket lens the bubbles in the glazes appear smaller and more numerous, near the BaO apex.

[1] A contribution from the Research Laboratories of the Champion Porcelain and Jeffery-Dewitt Insulator Companies, Detroit, Michigan. See Robt. Twells, Jr., "The Field of Porcelain Glazes Maturing between Cones 17 and 20," *Jour. Amer. Ceram. Soc.*, **5** [7], 430 (1922).

[2] Presented before the Whiteware Division, Pittsburgh Meeting, February, 1923.

When fired in the periodic kilns for 42 hours the transparency of all the glazes increases with the temperature. The glazes fired in the tunnel kiln to cone 19 flat in 31 hours are more opaque and smoother than in the periodic kiln at three cones lower temperature.

The triaxial replacement of the Florida kaolin, by North Carolina kaolin and Kentucky ball clay No. 4 produces relatively little change in the fired appearance. The glazes containing all ball clay or a mixture of ball clay and North Carolina kaolin overfire at a lower temperature than do those containing all kaolin or a mixture of Florida kaolin and ball clay.

The best glazes with 0.2 K_2O and 0.8 CaO have approximately an alumina: silica ratio of 1:9 and 1:11 for the field covered. These glazes are generally more transparent than the glazes with 0.3 K_2O; otherwise the results are similar.

The conclusions are: (1) that the nature of the firing conditions are of the utmost importance in the development of a glaze, and (2) that an intelligent choice between glazes of equally desirable appearance requires a resort to petrographic method and mechanical tests.

Introduction

Some time ago Sortwell[1] published the results of an investigation of porcelain glazes maturing between cones 10 and 16. A short time later the writer submitted a paper to the SOCIETY entitled, "The Field of Porcelain Glazes Maturing between Cones 17 and 20."[2]

These two investigations were studies of the effects of varying the molecular equivalents of alumina and silica while holding the RO members constant at 0.3 equivalent of K_2O and 0.7 equivalent of CaO.

From time to time these laboratories have had occasion to refer to both articles in order to write out at once the formula of a glaze for use at a particular temperature. When used in this way the diagrams have proved to be reliable even though in some cases the raw materials and the firing conditions were not exactly the same as in the original experiments.

The scarcity of published information regarding high temperature glazes has made it necessary to continue the work on this subject in an attempt to cover the whole field as completely as possible.

Methods of Experimentation

The work reported in this article consists of a study of three glaze series. The field covered by each series will be shown later in some detail. The methods used for making each series were the same. In each case the corner glazes only were weighed out and ground wet for 18 hours in small ball mills. The intermediate glazes were produced by cross blending the liquid corner glazes in the proper proportions as calculated from their relative specific gravities and molecular weights. Care was taken in all

[1] H. H. Sortwell, "High Fire Porcelain Glazes," *Jour. Amer. Ceram. Soc.*, **4** [9], 718 (1921).

[2] *Loc. cit.*

cases to obtain a thorough mixing of the component glazes. The body used had the same composition as in the previous experiment.

English ball clay (M. and M.)	5.0%
North Carolina kaolin	12.0
Florida kaolin	8.0
English china clay (M. W. M. No. 2)	30.0
Flint	30.0
Feldspar	15.0
	100.0%

The test pieces were made by extruding a column of the body one inch in diameter from a small hydraulic plunger press[1] and cutting it into $^3/_8$-inch lengths.

These discs were dried first in air; then in a laboratory steam drier, but were moistened with water just before being dipped into the glaze. The glazes were applied to the body in a much heavier coat than would ordinarily be used. The purpose of this was to magnify any defects of the glaze.

In each sagger was placed a cone pat containing three cones of the proper number. Around this was arranged a set of the discs, each coated with one of the glazes which went to make up a series. Some of the saggers were fired in different parts of downdraft periodic kilns. These kilns reached their maximum temperature in approximately forty-two hours. Some of the saggers were fired in a Dressler Tunnel Kiln,[2] when the cars were being put into the kiln once every hour. In this case the maximum temperature was reached in about thirty-one hours. One sagger was fired in the Dressler kiln when the cars were being put in an hour and one-half apart. In this case the maximum temperature was reached in approximately forty-six hours.

RAW MATERIALS USED

Feldspar—Maine Feldspar Co., Auburn, Maine.
Whiting—Solvay Process Co., Delray, Mich.
Flint—Pennsylvania Pulverizing Co., Hancock, W. Va.
Barium Carbonate—Mallinckrodt Chemical Works, St. Louis, Mo.
Talc—No. 1 White Brand—G. H. Gillespie Co., Madoc, Ontario, Canada.
Kentucky Ball Clay No. 4—Kentucky Construction and Improvement Co., Mayfield, Ky.
Florida Kaolin—Edgar Plastic Kaolin Co., Edgar, Fla.
North Carolina Kaolin—Harris Clay Mining Co., Spruce Pine, N. C.

With the exception of the talc all of the raw materials were assumed to have the same composition as the theoretically pure substances. From

[1] "Tentative Methods of Testing Electrical Porcelain," *Jour. Amer. Ceram. Soc.*, **5** [4], 83, Pt. II, *Year Book* (1922).

[2] "Preliminary Rept. of Comm. on Fuel Conservation on Railroad Tunnel Kiln," *Jour. Amer. Ceram. Soc.*, **5** [9], 609 (1922).

the average of four analyses the molecular composition of the talc was calculated to be:

$$\left.\begin{matrix}0.842\ MgO\\0.158\ CaO\end{matrix}\right\}\ 0.013\ Al_2O_3\ \ 0.91\ SiO_2\ \left\{\begin{matrix}0.158\ CO_2\\0.545\ H_2O\end{matrix}\right.\ \text{Molecular Weight 116.}$$

This formula was used as a basis when talc was introduced into Series A. The assumption that the other materials are pure caused errors which are negligible except in the case of the feldspar.

In series A and C a considerable error was introduced by the assumption that the feldspar used was a pure potash feldspar. The actual chemical analysis of the feldspar is approximately as shown below.

SiO_2	72.73%	
Al_2O_3	16.66	Molecular Composition
Fe_2O_3	0.12	
TiO_2	———	0.49 K_2O
CaO	Trace	0.25 Na_2O } 1.0 Al_2O_3 7.39 SiO_2
MgO	0.28	0.04 MgO 0.15 H_2O
K_2O	7.69	
Na_2O	2.54	Molecular Weight 612
Loss on Ignition	0.45	
	———	
	100.47%	

If one should wish to duplicate any of the glazes in these two series from the diagrams, it would be necessary to use a feldspar of approximately the same composition as given above, and to introduce it as though it were a pure potash feldspar. For practical purposes the results would then be similar to these. From a theoretical standpoint the error affects the interpretation of the results relatively little. This is because the error is chiefly in the RO group, and is practically the same for each glaze in the series. The extent of the variation of the actual composition of the corner glazes from their theoretical compositions will be shown later.

Methods of Examining the Fired Glazes and Reporting the Results

After each series had been fired in several different ways, the glazed test pieces were sorted out into their respective positions. Each set of glazes was inspected twice: first with the naked eye, and second with a Bausch and Lomb 10 X Triple Aplanat magnifying glass. The results of these examinations are described for each set of glazes. Whenever practical, the results are also shown by means of diagrams:

Series A

The purpose of this series was to study the effect of replacing CaO by MgO and BaO in one of the best glazes from the previous work. The glaze:

$$\left.\begin{matrix}0.3\ K_2O\\0.7\ CaO\end{matrix}\right\}\ 1.3\ Al_2O_3 \qquad 11.0\ SiO_2$$

was chosen for a basis for this experiment because it seems centrally located in the area of good glazes at these temperatures. The field covered may be seen by reference to Fig. 1.[1]

The number of molecular equivalents of K_2O, Al_2O_3 and SiO_2 was held constant; the CaO was varied between 0.2 and 0.7 equivalents, being

Percentage Composition of the Corner Glazes

Glaze No	A1	A16	A21
Feldspar	18.0	17.10	18.5
Whiting	7.6	2.05	1.2
Talc	-	-	7.6
$BaCO_3$	-	10.10	-
Flint	46.6	44.3	44.3
Fla. Kaolin	27.8	26.45	28.4

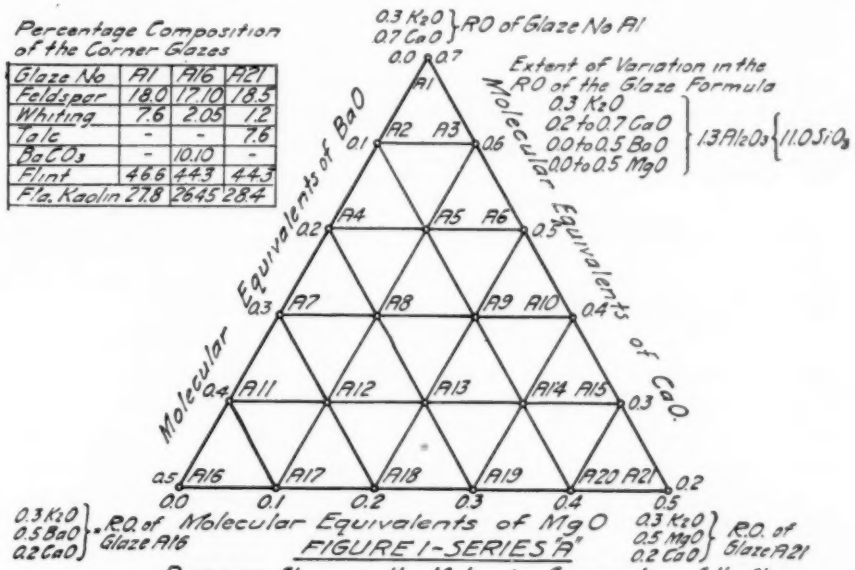

0.3 K2O 0.7 CaO } RO of Glaze No A1
Extent of Variation in the RO of the Glaze Formula
0.3 K2O
0.2 to 0.7 CaO
0.0 to 0.5 BaO
0.0 to 0.5 MgO
} 1.3 Al2O3 { 11.0 SiO2
Molecular Equivalents of BaO
Molecular Equivalents of CaO
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21
0.0 0.1 0.2 0.3 0.4 0.5
0.3 K2O 0.5 BaO 0.2 CaO } R.O. of Glaze A16
Molecular Equivalents of MgO
0.3 K2O 0.5 MgO 0.2 CaO } R.O. of Glaze A21

FIGURE 1-SERIES "A"

Diagram Showing the Molecular Composition of the Glaze

replaced triaxially by BaO and MgO. The MgO was derived from talc which has some advantages over its other possible sources.[2]

[1] The molecular compositions given in Fig. 1 are theoretically based on the introduction of the feldspar as a pure potash feldspar instead of according to its chemical composition. Based upon the latter, the actual molecular formulae of the three corner glazes in Series A are calculated to be as shown below:

$$\begin{matrix}\text{A–1} & \left.\begin{matrix}0.22\ KNaO\\0.01\ MgO\\0.77\ CaO\end{matrix}\right\} & 1.39\ Al_2O_3 & 12.2\ SiO_2\\ \text{A–16} & \left.\begin{matrix}0.22\ KNaO\\0.01\ MgO\\0.22\ CaO\\0.55\ BaO\end{matrix}\right\} & 1.42\ Al_2O_3 & 12.35\ SiO_2\\ \text{A–21} & \left.\begin{matrix}0.23\ KNaO\\0.22\ CaO\\0.55\ MgO\end{matrix}\right\} & 1.48\ Al_2O_3 & 12.5\ SiO_2\end{matrix}$$

[2] Robt. Twells, Jr., "Talc as a Flux for High Tension Insulator Porcelains," *Jour. Amer. Ceram. Soc.*, **5** [10], 678 (1922).

Appearance of the Fired Glazes

Cone 16$^1/_2$, Periodic Kiln, 42-Hour Burn.—(1) Naked Eye: The glazes are all similar. They are smooth and semi-opaque. On the whole their appearance is pleasing. Glazes A-1, A-3, A-4, A-8, A-12 and A-15 contain one or more open bubbles at the surface which would tend to catch dirt.

(2) Magnifying Glass: On the CaO and MgO side of the triangle the glazes contain a net-work of large bubbles interspersed with smaller ones. At and near the BaO apex the glazes contain numerous small bubbles with an occasional larger one.

Cone 16$^3/_4$, Cone 17 Just Started, Periodic Kiln, 42-Hour Burn.—(1) Naked Eye: All of the glazes have a smooth appearance. Practically no difference can be detected between them. They are more nearly transparent than at cone 16$^1/_2$, but still are partly opaque. At the surface of glazes A-1, A-13, A-16, A-18 and A-21 there are one or more open bubbles.

(2) Magnifying Glass: The glazes contain a net-work of medium-sized bubbles with an occasional larger one. The bubbles in A-16 appear small but more numerous than in the others.

Cone 17 Down, 18, Just Tipped, Periodic Kiln, 42-Hour Burn.—(1) Naked Eye: The glazes are all bright and transparent, with the exception of A-16, which seems to be somewhat cloudy. Close observation discloses minute bubbles in all of the glazes which are visible to the naked eye. Glazes A-7, A-11, A-12 and A-21 have open bubbles at the surface.

(2) Magnifying Glass: The glazes all contain a net-work of medium-sized bubbles, with an occasional larger bubble, with the exception of A-16. It contains a great many fine bubbles with an occasional large bubble.

Cone 18 Down, 19$^1/_4$, Periodic Kiln, 42-Hour Burn.—(1) Naked Eye: The glazes are all bright and very transparent. A few small bubbles are visible on close observation. Glazes A-3, A-6, A-7, A-11, A-13, A-17 and A-21 contain one or more open bubbles at the surface.

(2) Magnifying Glass: A-16 contains very fine bubbles and a few big ones. The rest contain medium-sized bubbles with an occasional larger one.

Cone 19 Flat, Dressler Kiln, 31-Hour Burn.—(1) Naked Eye: All of the glazes are very smooth, very white, and almost opaque. There are no open bubbles visible at the surface.

(2) Magnifying Glass: All of the glazes contain many minute bubbles with an occasional larger one.

Conclusions.—Within the limits of this experiment the triaxial replacement of CaO by BaO and MgO does not produce a noticeable change in the appearance of the fired glazes. Under the magnifying glass, the glazes near the BaO apex contain somewhat smaller bubbles than those at either the CaO or MgO apexes. When fired under similar conditions

in the periodic kilns the transparency of the glazes tends to increase with the temperature. This is also true of the number of bubbles in the glazes visible to the naked eye. On the contrary the number of open bubbles at the surface of the glazes does not seem to depend upon either the composition of the glaze or the temperature of the firing. They seem to occur at random. It is interesting to note the improved appearance of the glazes fired in the Dressler kiln with the short firing period. At cone 19 flat these glazes are more opaque than those from the periodic kiln at cone $16^1/_2$. The absence of the open bubbles at the surface of the glazes when fired in this way is also encouraging.

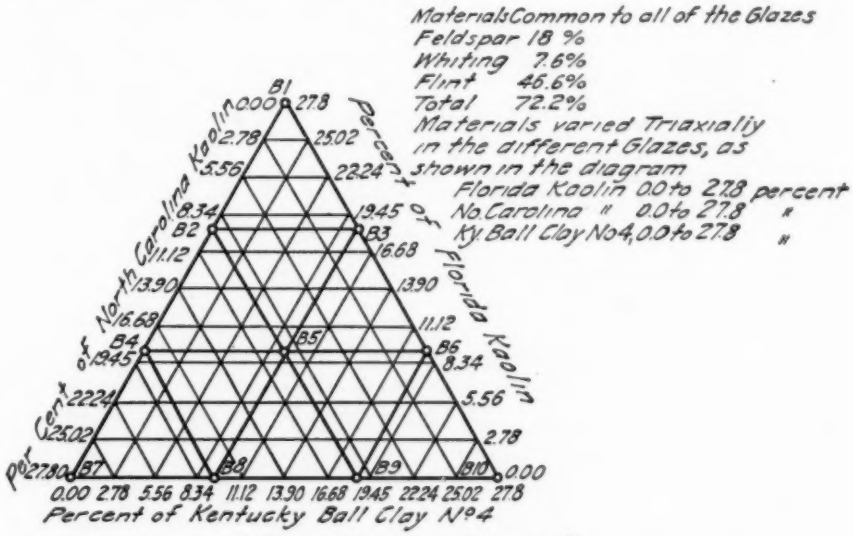


FIGURE 2 SERIES "B"
Diagram Showing the Percentage Composition of the Glazes

Series B

The purpose of this series was to determine the effects on the fired appearance of a glaze due to replacing Florida kaolin triaxially with Kentucky ball clay and North Carolina kaolin. Glaze A-1, from the previous series, was used as a basis for this experiment. The method of laying out the series and the composition of the glazes may be seen by reference to Fig. 2.

Appearance of the Fired Glazes

Cone 16 Down, 17 Just Started, Periodic Kiln, 42-Hour Burn.—(1) Naked Eye: All of the glazes appear smooth and semi-opaque, except B-9, which seems rough.

(2) Magnifying Glass: The glazes all contain many small bubbles and a few large ones. Glaze B-9 has a lot of open bubbles at the surface.

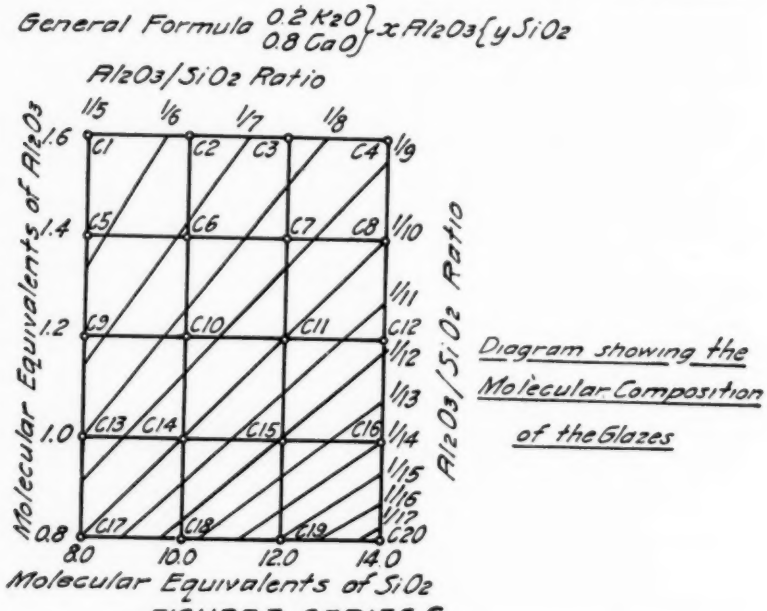
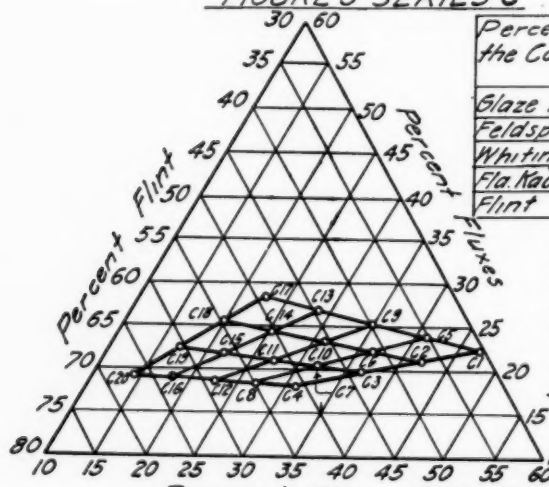


Diagram showing the Molecular Composition of the Glazes

FIGURE 3 SERIES C



Percentage Composition of the Corner Glazes				
Glaze No	C1	C4	C17	C20
Feldspar	14.1	9.65	16.3	10.65
Whiting	10.1	6.95	11.7	7.70
Fla. Kaolin	45.5	31.30	22.7	14.85
Flint	30.3	52.10	49.3	66.80
	100.0	100.0	100.0	100.0

The percent of fluxes given is the sum of the whiting & the Feldspar

In each case the ratio $\frac{\text{Feldspar}}{\text{Whiting}} = 1.39$

FIGURE 4 SERIES C

Diagram Showing the Percent Composition of the Glazes

Cone 17 Down, 18 Tipped, Periodic Kiln, 42-Hour Burn.—(1) Naked Eye: The glazes are similar in appearance. All are smooth glazes, slightly more transparent than at cone 16 down.

(2) Magnifying Glass: The glazes all contain small bubbles interspersed with larger bubbles.

Cone 18 Down, 19¼, Periodic Kiln, 42-Hour Burn.—(1) Naked Eye: All of the glazes have a smooth appearance except B-8 and B-9, which contain a few open bubbles at the surface. The glazes are slightly more transparent than at cone 17 down, but are still somewhat opaque. B-8, B-9 and B-10 are noticeably more transparent than the others. This is particularly true of B-9.

(2) Magnifying Glass: All of the glazes except B-9 and B-10 contain a lot of medium-sized bubbles and a few larger ones. The bubbles in B-9 are mostly large ones, but are not as numerous. B-10 contains a lot of bubbles, some of which are very large.

Cone 19 Flat, Dressler Kiln, 31-Hour Burn.—(1) Naked Eye: All of the glazes are smooth, white and semi-opaque.

(2) Magnifying Glass: The glazes all contain many fine bubbles. A few of the bubbles are larger than the rest.

Conclusions.—As would be expected, the glaze made with Kentucky ball clay tends to overfire a little sooner than the glazes made with either North Carolina or Florida kaolin. There seems, moreover, to be a eutectic action between the glaze made with North Carolina kaolin and the glaze made with Kentucky ball clay as shown by the fact that B-9 tends to overfire at a lower temperature than either B-7 or B-10. This same action, however, is not noticeable between the ball clay and the Florida kaolin, nor between the latter and the North Carolina kaolin. There is practically no difference in the color of the glazes. In this series, as in series A, the glazes fired in the Dressler kiln with a short firing period are much superior to those fired in the periodic kilns, even though the firing temperature is much higher in the former case.

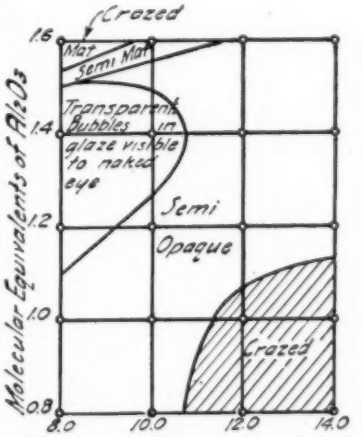


FIGURE 5

General Glaze Formula

$$\left.\begin{matrix} 0.2\ K_2O \\ 0.8\ CaO \end{matrix}\right\} \times Al_2O_3 \left\{ y\ SiO_2. \right.$$

Series C

Porcelain glazes maturing between cones 9 and 12 usually contain theoretically nearly 0.3 of an equivalent of K_2O. This figure was naturally used by the writer in his previous work on high temperature glazes. There are, however, some grounds for questioning whether this is not too high

an alkali content for temperatures between cones 17 and 20. Accordingly, a series of glazes was made in which the RO was held constant at 0.2 equivalents of K_2O and 0.8 equivalents of CaO, while the Al_2O_3 was varied between 0.8 and 1.6 equivalents, and the SiO_2 between 8.0 and 14.0 equivalents. (Figs. 3 and 4.)[1]

Appearance of the Fired Glazes

Cone 18½, Dressler Kiln, 31-Hour Burn.—(1) Naked Eye: The results may be best understood by reference to Figs. 5 and 6. Crazing occurs

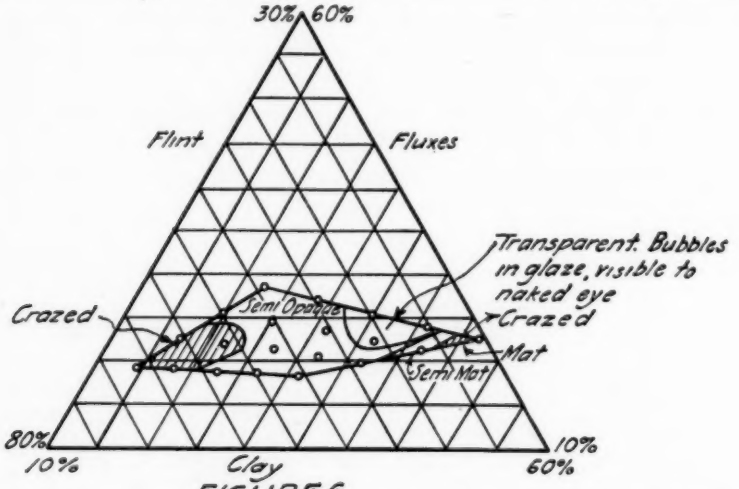


FIGURE 6

Series C. Results at Cone 18½ Dressler Kiln- 31 Hour Burn

with an alumina:silica ratio of 1:12 and less. This is in the region of high flint. It also occurs slightly with a ratio of 1:5 in the region of high clay. Glaze C-1 with an alumina:silica ratio of 1:5 at 8.0 equivalents of silica is an aluminous matt. The area in the diagram marked "Transparent. Bubbles in glaze visible to naked eye" corresponds to that in the previous article marked[2] "Smooth, Transparent." In each case

[1] The diagrams for series C are based upon the assumption that the feldspar used was a pure potash feldspar. The actual molecular formulae of the four corner glazes as calculated using the chemical analysis of the feldspar, are shown below:

C–1	0.145 KNaO 0.855 CaO	1.67 Al_2O_3 8.6 SiO_2
C–4	0.145 KNaO 0.855 CaO	1.68 Al_2O_3 15.0 SiO_2
C–17	0.145 KNaO 0.855 CaO	0.835 Al_2O_3 8.6 SiO_2
C–20	0.145 KNaO 0.855 CaO	0.827 Al_2O_3 14.9 SiO_2

[2] Twells, *loc. cit.*, **5** [7], 430 (1922).

these glazes are probably approaching overfiring. This is especially true of C-5 which contains many bubbles and has a tendency to sink into the body. The best glazes are those in the area marked "Semi-Opaque," which corresponds to the areas marked "Smooth, Opaque" in the previous article. These best glazes lie approximately between the alumina: silica ratio lines 1:8 and 1:11.

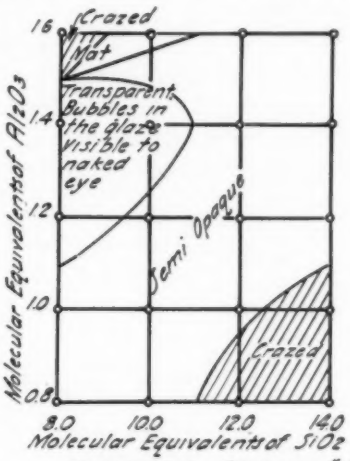


FIGURE 7 SERIES "C"

General Glaze Formula

$$\left.\begin{matrix}0.2K_2O\\0.8CaO\end{matrix}\right\} \times Al_2O_3 \left\{ y\ SiO_2.\right.$$

(2) Magnifying Glass: The matt glaze, C-1, has an egg shell surface containing many indentations. The glazes marked "Transparent" contain many large bubbles interspersed with smaller ones. Some of the large bubbles are open at the surface of the glazes. The glazes marked "Semi-Opaque" all contain a great many small bubbles interspersed with an occasional larger one. These larger bubbles increase in number near glaze C-17 in the region of high fluxes.

Cone 19½, Dressler Kiln, 31-Hour Burn (Figs. 7 and 8).—(1) Naked Eye: The results are similar to those already described at cone 18⅓. The area of crazed glazes in the region of high flint has decreased somewhat. Their alumina: silica ratio is now about 1:13 or less. The char-

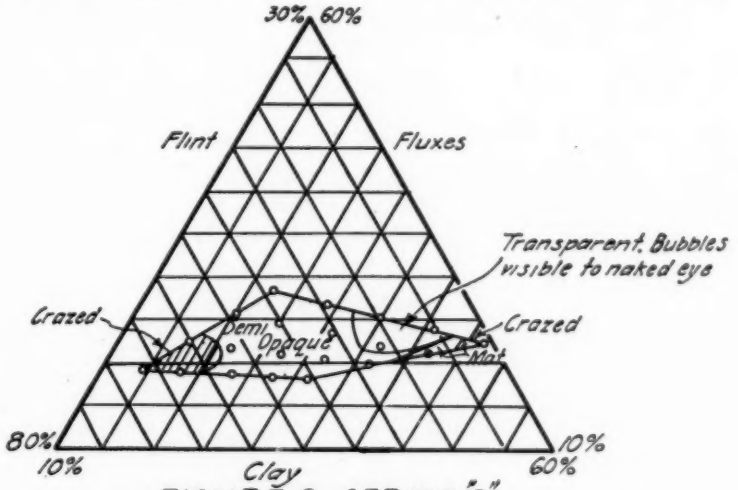


FIGURE 8 SERIES "C"

Results at Cone 19½. Dressler Kiln 31 Hour Burn

acter of the crazing of C-16 has changed from fine to coarse. The area of matt glazes has extended to include C-2, which is next to C-1 in containing a high percentage of clay. Glaze C-5 is more nearly over-fired than at cone $18^1/_3$. The area of the best glazes lies probably between an alumina: silica ratio of 1:8 and 1:12.

(2) Magnifying Glass: The results are similar to those already described at cone $18^1/_3$.

Cone 19 Flat, Dressler Kiln, 46-Hour Burn (Figs. 9 and 10).—(1) Naked Eye: The crazed and matt areas are similar to those at cone $19^1/_2$. The chief change at this temperature is in the area of the transparent glazes, which is extended in the direction of the high flint. Glaze C-5 is badly sunken into the body. The other glazes in this area are also near overfiring. Glaze C-16 acted peculiarly under these firing conditions. The disagreement between the body and the glaze was so great that the glaze actually split off, taking a thin layer of the body with it; yet the glaze is crazed. The area of the best glazes is somewhat reduced in size. It extends from an alumina: silica ratio of 1:9 to 1:12.

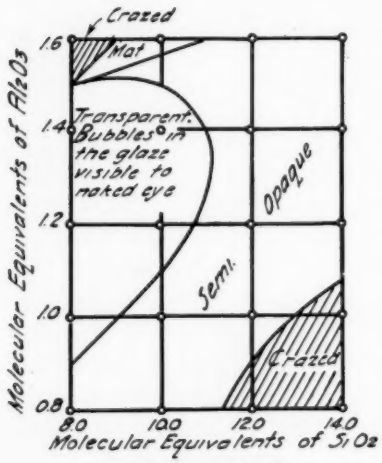


FIGURE 9

General Glaze Formula

$$\left.\begin{matrix}0.2K_2O\\0.8CaO\end{matrix}\right\} \times Al_2O_3 \left\{ y\ SiO_2.\right.$$

(2) Magnifying Glass: The results are similar to those at cone $18^1/_3$ except that on the whole the bubbles are larger and more apparent, particularly in the region marked "Transparent," and in the glazes with the highest percentage of fluxes. This is not true of the open bubbles at the surfaces of the glazes. These seem more frequent at cone $18^1/_3$ than at the two higher temperatures.

Conclusions—For temperatures ranging between cone $18^1/_3$ and 19 flat, a glaze with an RO of $\left.\begin{matrix}0.2\ K_2O\\0.8CaO\end{matrix}\right\}$ should, as a rule, have an alumina: silica ratio between 1:9 and 1:11 for 8.0 to 14.0 equivalents of silica. These limits do not include C-3, C-4, C-7 and C-12, all of which are good glazes. In fact, under these conditions, the best glazes for general appearance in this series are C-4, C-7, C-8 and C-11, whose approximate limits of compositions are:

Feldspar	9.5 to 12.0%	Clay	27.5 to 31.5%
Whiting	7.0 to 8.5%	Flint	50.0 to 55.5%

This area does not fall near the similar area already picked as containing the best glazes with 0.3 equivalents of K_2O.[1] This is not due as much to actual differences in the appearance of the two-glaze series as it is due to changes in the methods of studying the fired glazes. As a matter of fact, considering the difference in grinding, the results obtained with 0.2 equivalents of K_2O coincide closely with those previously obtained with 0.3 equivalents of K_2O. In the latter case the writer would now pick as the best glazes those with higher equivalents of alumina and silica than he did previously. This would make the best glaze areas in the two series practically coincident.

As has already been stated, relatively little difference can be detected

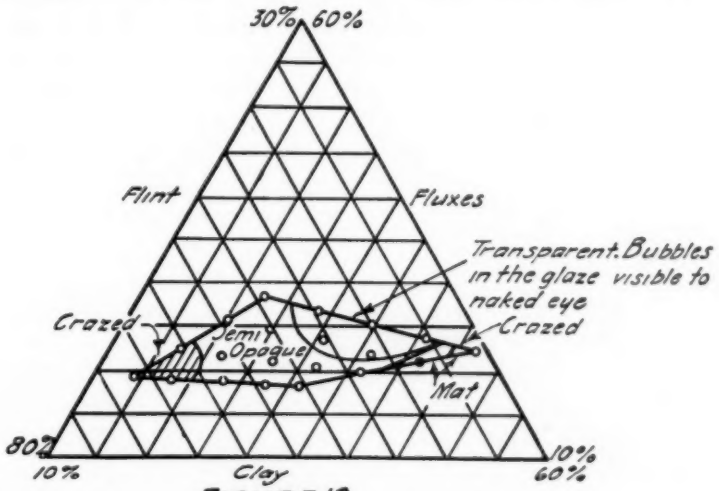


FIGURE 10
Series C. Results at cone 19 Flat. Dressler Kiln.
46 Hour Burn

between the glazes containing 0.3 K_2O and 0.2 K_2O. The latter seem more transparent although this may be due partly to having been ground for a longer time.[2]

General Conclusions

In the proper development of a glaze the firing conditions are of the utmost importance. The kind of kiln, the firing curve, the cooling curve, and the nature of the kiln gases, all greatly affect the resulting structure and appearance of the finished glaze.

[1] Twells, *Jour. Amer. Ceram. Soc.*, **5** [7], 439 (1922).

[2] This agrees with the opinion of Emile Bourry, "A Treatise on Ceramic Industries," p. 436, 3d. ed.

The method of choosing a glaze is important. These methods show that there are a great many combinations of materials which will produce good glazes, as far as outward appearance is concerned. Unfortunately, however, a superficial examination alone does not give sufficient information as to the relative qualities of glazes which are apparently equally as good. Even a pocket lens shows great differences in the nature of the bubbles which they contain. Information of still greater value can be obtained through the use of a petrographic microscope. Again, as Riddle and Laird have brought out, glazes differ widely in "fit" with the body, although the compositions and appearances of the glazes may be similar.[1] For determining the "fit," they have demonstrated the value of mechanical tests, which show accurately the effect of the glazes upon the strength of a body. With these things in mind, it would seem that petrographic methods and mechanical tests are almost necessities for intelligently differentiating between glazes which would otherwise appear equally desirable.

At the end of section "Series A" of Mr. Twells's paper, the following discussion occurred:

H. S. SPURRIER:—Was the atmosphere in the kiln a neutral atmosphere?

R. TWELLS:—The atmosphere in the hot zone of the tunnel kiln was slightly reducing.

H. S. SPURRIER:—Have you noticed the difference in this as compared with the periodic kilns?

R. TWELLS:—The glazes described in this article as having been fired in periodic kilns were undoubtedly subjected to a kiln atmosphere of a more oxidizing nature than those fired in the tunnel kiln.

H. S. SPURRIER:—As the temperature goes up, are there more unbroken bubbles?

R. TWELLS:—Yes, provided the kiln conditions are the same in each case.

H. S. SPURRIER:—You find the surface bubble is nearly eliminated?

R. TWELLS:—The broken bubbles at the surface of the glaze seem more largely dependent on kiln atmosphere than on temperature.

H. S. SPURRIER:—Of course you pass a point where all carbonates decompose, and there comes a point where atmosphere absorbed by the glaze is regenerated and separated just as in the elimination of seeds in glass.

At the end of section "Series B" of Mr. Twells's paper, the following discussion occurred:

H. S. SPURRIER:—Would you attribute the better glaze to the atmosphere or time factor?

[1] F. H. Riddle and J. S. Laird, "The Control of Glaze-Fit by Means of Tensile Test Specimens," *Jour. Amer. Ceram. Soc.*, **5** [8], 500 (1922).

R. TWELLS:—I would be inclined to say it was due to a little of both, mostly to the atmosphere, and to a smaller extent, the time. We get very good results in a surface combustion kiln in the laboratory, firing on the short firing schedule, but we sometimes get open bubbles in the glaze even though it is a short firing period. In the Dressler kiln we are able to control the kiln atmosphere very closely.

H. S. SPURRIER:—What was the carbonate lime content? Was it allowed for? Was that in your CaO equivalent?

R. TWELLS:—The lime in the talc was allowed for in figuring out the glaze in which talc was used. That is the reason that I stopped in series A with 0.2 CaO instead of eliminating the CaO entirely. This was not possible unless I used some other source of MgO than talc. The CO_2 content in the talc was not determined by analysis, but was assumed to be present as $CaCO_3$. The CaO content in the talc ran about 7%.

TEMPERATURE CONTROL OF DRESSLER TUNNEL KILN[1]

By T. R. Harrison

ABSTRACT

The method of graded adjustment of fuel supply was adopted. Adjustments to compensate for variations in quality of fuel gas, which often amounted to as high as 30% change in the gas pressure at the burners within two or three minutes, are produced through the agency of the variation in the length of a bunsen burner flame as different kinds of gas are supplied under the same pressure. The adjustment is thus made without the temperature departing from the desired value.

Further minor adjustments are made according to slight departures from normal of the combustion chamber temperatures. The pyrometer control contacts are moved away from the normal position simultaneously as the gas pressure is adjusted, the magnitude of this adjustment being proportional to the necessary motion of the contact points to bring them to the momentary position of the pyrometer pointer. The contact points are then automatically returned to their normal position at a predetermined (constant or variable) rate which is the estimated rate at which the kiln should return to its normal value when the correct adjustment has been made. A sufficient correction is thus made promptly without over-correction during the necessary period of recovery as demanded by the kiln lag.

Introduction

Conditions to be considered in firing the Dressler tunnel kiln of the Champion Porcelain Company include temperature at hottest section along tunnel, length of heat zone, and analyses of the tunnel gases at various points.

On account of the large volume of the kiln, and the necessity of holding the flames of the main burners as long as possible in order to produce a long maturing zone, no serious consideration was given to the most popular method of temperature control whereby the heat supply is operated intermittently between a high and low value. Other considerations entered also, for example, the fact that most of the combustion air is forced into the kiln past the exit cars, preheating the air and cooling the cars. Even if this could be controlled along with the gas it would be most likely to produce surges of gases up and down the tunnel, disturbing the delicate balance which maintains the proper distribution of tunnel atmosphere.

The most serious condition to be met in firing this particular kiln is the variation in quality of the city gas which is used as fuel. At times this may be coal gas or coke oven gas and at other times water gas or mixtures of the two. As compared with hydrogen, the density of the coal gas is about 5.9 and that of the water gas is about 8.8.[2]

Variations in Gas Supplied

Curve A, Fig. 1 indicates the variations which occurred in the density of the gas as supplied to the kiln during one twenty-four hour period.

[1] Presented by J. A. Jeffery, Summer Meeting, American Ceramic Society, Detroit, Aug., 1923.

[2] The figures here given are not exact in all cases.

Coal gas has lower density and hence under given conditions of valve opening and pressure the flow would be about 20% greater than with water gas, and since the heating value of coal gas is greater also, these conditions combine to raise the temperature of the kiln when coal gas follows water gas.

Methods of Control

In order to maintain the temperature constant the gas pressure at the burners must be varied according to the gas changes as indicated by curve B. Curves A and B are taken from the charts of recording meters. Sketch C shows the piping arrangements of the gas supply line with the main

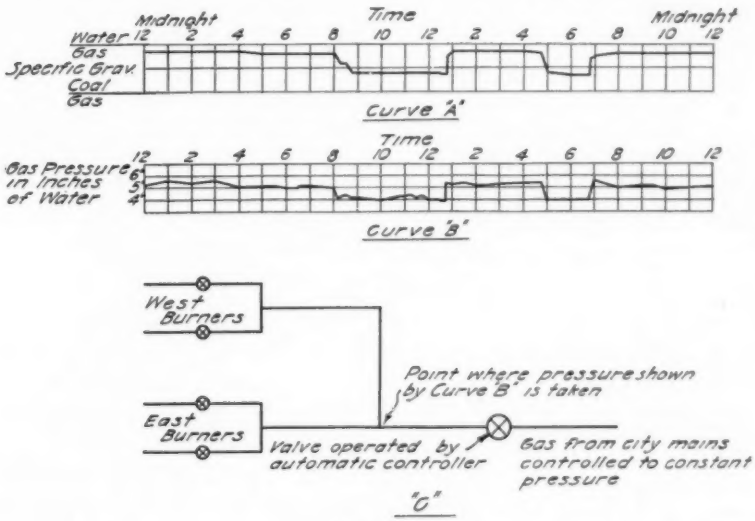


FIG. 1.

control valve, the connection to the pressure gage and the burners and valves. These individual burner valves are adjusted separately to permanent positions.

The Controller.—The main burden of the controller is borne by a part of the mechanism which operates the control valve according to changes in gas quality. This operates accurately enough so that the temperature of the kiln would hold fairly constant without further adjustment as is shown by comparing curves A and B of Fig. 1. It will be seen that when the specific gravity of the gas changes, the controller makes a proportionate change in the gas pressure and the pressure is further adjusted only very slightly by another mechanism, operating according to temperature, to maintain a constant temperature within the kiln.

Control of Variations not Due to Gas Quality.—A slight waviness

is observed in the pressure at times when the gas is of constant quality, this being clearly seen between midnight and 8 A.M. These smaller adjustments are made by a part of the controller which operates when the temperature tends to drift away from the desired value. These waves agree in period with the schedule of the cars, this agreement holding quite consistently.

Control of Variations Due to Gas Quality.—Figures 2, 3 and 4 show the principle of operation of that part of the controller which operates according to gas quality. This makes the necessary adjustments so promptly after the quality changes that the temperature makes practically no deviation from normal.

The Bunsen Burner Basic Means of Adjustments.—The flame of a bunsen burner is the basic means of making these adjustments. When a bunsen burner is supplied with gas from the mains the length of the flame and of the central cone will vary according to the quality of the gas. While the rate of flame propagation in the gas is doubtless different for different kinds of gas, the more important causes of the difference in flame length are probably viscosity, or rate of flow, and the amount of air required for combustion.

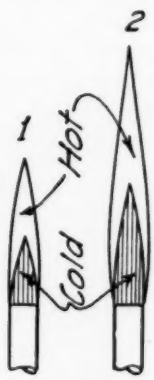


FIG. 2.

Water gas Coal gas
Bunsen flames

As compared with water gas, coal gas requires about 10% more air for combustion and about 20% more gas flows through the burner, hence the increase in flame length would be about equivalent to what would be caused by increasing the flow of any one kind of gas by 30% without increasing the air.

A burner supplied with gas at uniform pressure will burn with flames as indicated at 1 and 2 (Fig. 2) when supplied with water gas and coal gas. At 3, Fig. 3, is indicated the principle by means of which a differential thermocouple sets up currents which operate to bring the couple to a definite position with reference to the length of the flame.

Figure 4 shows the manner in which this is accomplished while simultaneously making a suitable change in the setting of the gas valve.

To illustrate the operation let it be assumed that the gas is changing to a higher proportion of coal gas at 1, this makes a longer flame, cooling the lower junction and heating the upper junction of thermocouple 2, thus setting up a thermoelectric current as indicated by the arrow. This causes galvanometer 3 to deflect and operate a relay which turns disc 4 (shown in solid line) in the direction indicated. Disc 4 rotates lever 5 and thus raises the couple until both junctions again come to the same temperature.

Disc 4 also moves electrical contact 6 away from dead point 7 into elec-

trical contact with segment 8*H*. This contact energizes the valve operating mechanism 9 which commences operating to partially close the main gas valve by means of sprocket 10.

Simultaneously mechanism 9, being belted to the disc 11 (shown dotted) which carries segments 8*H* and 8*L*, will rotate disc 11 until dead point 7 again reaches contact 6 and the operation will be stopped.

Thus the amount of adjustment of the valve will be proportional to the change in length of the flame.

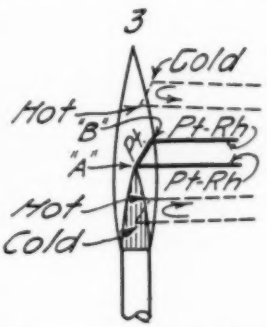


FIG. 3.—A differential thermocouple operates to hold its lower junction on the top of the inside cone of the flame, raising or lowering with the changes in gas quality. Thermoelectric current flows in direction of arrow when couple is too high. No current flows when junctions *A* and *B* are at the same temperature. Current flows in opposite direction when couple is too low. Thermoelectric currents deflect galvanometer and operate mechanism to bring differential couple to the central position. This also moves a contact which causes the gas valve to be opened or closed.

Maintenance of Constant Kiln Temperatures

As already indicated, finer adjustments must be made from time to time to correct any tendency for the temperature to drift away from the normal value.

For this purpose six thermocouples are placed with their junctions between the double walls of the combustion chambers, three couples on either side. These are placed several feet apart along the hottest section of the chambers and register promptly any drift in the temperature, adjusting the valve to correct the condition.

The couples are connected in series, making the apparatus six times as sensitive and causing the controller to operate to keep the average temperature of all six couples constant rather than controlling according to the temperature at any one point.

Corrections are made so promptly that the average temperature of the chambers usually stays constant to within plus or minus two degrees centigrade.

The operation of this mechanism will be explained by considering the case where the kiln begins losing temperature.

Referring to Fig. 5, if the temperature starts to get low the galvanometer pointer 1 makes electrical contact with point 2*L*. This energizes the mechanism 3 to turn sprocket 4 and open the gas valve. Mechanism 3 also turns bevel gears 5 and arm 6 which carries the contacts 2*H* and 2*L*. This operation continues until arm 6 has moved as far as the pointer moves, then operation ceases. Thus the gas is increased proportionally to the error in temperature, enough for recovery and no more.

Kiln lag causes temperature recovery to be slow. When arm 6 is moved

away from its normal position N an escapement mechanism 7 automatically returns it to N at a slow rate without moving the valve. There is no further valve adjustment as long as the kiln returns to its normal temperature at this same rate.

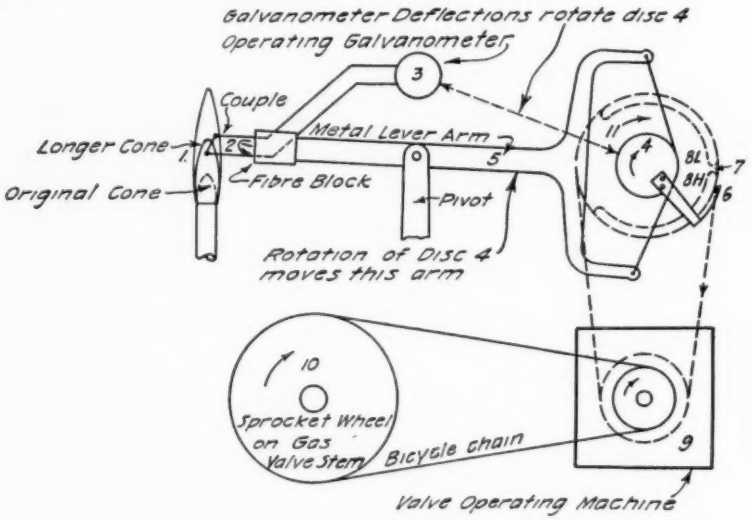


FIG. 4.—Mechanism for controlling gas pressure according to quality.

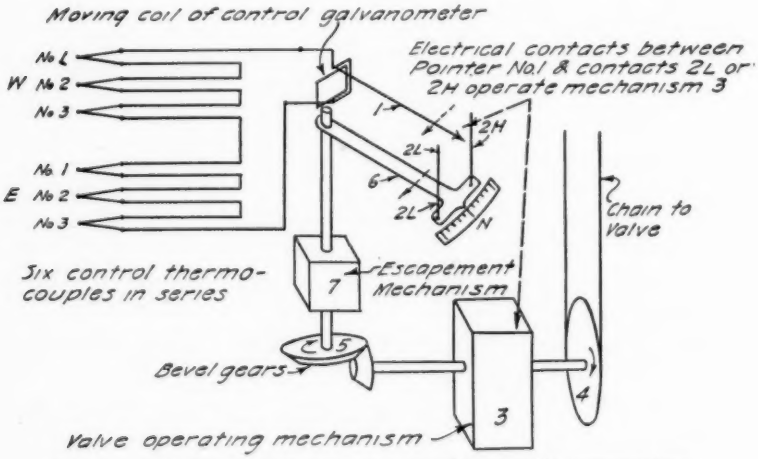


FIG. 5.—Additional control of gas according to kiln temperature.

If the temperature recovers more rapidly than the rate of return of arm 6 contact will be made between points 1 and $2H$, operating to reduce the valve opening, so that by the time the normal temperature has been reached the gas pressure will be properly adjusted to hold it there.

On the other hand, if the temperature recovers too slowly the escapement will cause contact to be again made at $2L$ and thus open the valve more. Thus enough correction will always be made to return the kiln to its normal temperature but the mechanism operates to prevent the temperature going too far in the other direction.

The movable arm 6 and escapement mechanism 7 are additions to a standard temperature controller which make it operate successfully on a kiln having such a long lag. Before these additions were made the standard machine would cause the pressure to vary continuously, sometimes going up and down between 2 inches and 7 inches with constant gas quality. Even setting the escapement mechanism 7 to operate three times as rapidly as it now does caused the gas pressure to "hunt" over a range of $1^1/_2$ inches.

The machines shown in Figs. 4 and 5 are combined to operate upon the same valve by means of a suitable switching arrangement and clutches.

Gas Control by Pressure

In a new controller now being designed the gas will be controlled according to its pressure rather than the valve setting. This will then compensate for variations in the pressure of the supply gas without waiting for the temperature to be affected and will also eliminate inaccurate adjustments caused by back-lash in valves.

The new controller will control the air supply in conjunction with the gas. Also, pyrometers near the ends of the combustion chamber flames will operate the air supply to maintain a constant length of flames and heating zone, making corrections for variations of fan speed, temperature of intake air, and other variables which cause irregularity in the oxygen supply.

At present it appears most probable that the gas for the main burners will be controlled according to gas quality and combustion chamber temperature; the "auxiliary" or tunnel gas according to gas quality and analysis of tunnel gases, and the air or oxygen will be controlled according to gas quality (only slight adjustment believed to be required), combustion chamber temperature in hottest section (varying with equivalent adjustments of gas of constant quality) and combustion chamber temperature near the ends of the flames, the latter maintaining the correct ratio between gas and air throughout the various conditions surrounding the kiln in its continuous operation.

CHAMPION PORCELAIN COMPANY
DETROIT, MICHIGAN

NOTE ON THE HEAT DISTRIBUTION IN UPDRAFT KILNS[1]

By A. V. Bleininger

ABSTRACT

In the pottery updraft kiln the rising gas currents tend to separate into distinct streams which follow the lines of least resistance in making their exit through the kiln crown. The draft while weak at first becomes very strong during the heat raising period and emphasizes the vertical stratification of the gases. In using natural gas as fuel complete combustion is not usually attained during the period of maximum firing and CO is invariably found present.

The irregularity of the heat distribution is chiefly due to the formation of distinct gas currents and the long soaking of the top in order to secure proper heating of the bottom. Remedies proposed are slower raising of the heat in order to secure top and bottom temperatures more nearly equal and reducing the time of the soaking period which is often excessive; the use of dampers for the control of the draft; and the employment of low pressure forced draft. It is believed that in the future the application of positive pressure will prove most effective in securing more economical firing in all types of periodic kilns.

Introduction

The Kiln.—The problems of heat distribution are no less complex than those of heat generation and they are particularly so in the updraft kilns of the pottery industries.

We are dealing here with bisque kilns which are 18 ft. in diameter and have a height of 13 ft. to the shoulder of the crown which has a rise of 3 ft. The glost kilns have a diameter of 16 ft. 6 in., a height of 14 ft. to the shoulder of the crown and a rise of 2 ft. The bisque kilns have a capacity of 3750 and the glost kilns of 3300 cubic feet and are fired with natural gas. All of these kilns have ten furnaces and the gases as they emerge from the furnaces are split into two streams, one of which goes under the floor to the well hole from which it rises, and the other ascends through the bag into the kiln space. The exit of the gases is through a ring hole 14 inches in diameter and through 30 slick holes, $4^1/_2$ by $2^1/_4$ inches, three of the latter being provided for each furnace. All of these are spaced in the crown fairly symmetrically.

Factors in Heat Distribution

Velocity of the Gases.—The direction of the gases is upward and the heat distribution throughout the five sections known as quarters depends upon the volume and the temperature of the combustion gases, their velocity, the rate of firing and the duration of the soaking period.

It is obvious that the velocity of the gases is slow at first due to the sluggish draft. It then increases until it may become excessive toward the end of the burn. This raises the interesting question as to the relation

[1] Presented before Whitewares Division, Pittsburgh Meeting, Feb., 1923.

between the velocity of the gases and the heat transmitted and as to whether it conforms in general to Reynold's law:[1]

$H = At + Bdvt$, where
H = heat transmitted per unit time and per unit surface,
A and B are constants,
d = density of the heat carrying fluid,
v = velocity, and
t = difference in temperature between the heat carrying medium and the surface.

While this law seems to apply satisfactorily to many conditions of heat transfer its constants remain to be determined for the conditions existing in ceramic kilns.

Time Factor.—It is evident also that the time factor as in all heating processes is exceedingly important. This involves both the rate of heating and the time one portion of the kiln is held at a constant temperature in order to reach the desired heat intensity in another. The top of the kiln setting usually reaches the maximum temperature first and by soaking it is caused to extend to the bottom, a procedure which is assisted by the increasing heat accumulation of the kiln floor. The increasing thermal conductivity of the saggers with temperature is also a factor to be considered. The method of first obtaining the maximum temperature on top is by no means desirable and it would be much better if we could maintain smaller temperature differences from the beginning of the firing. This would avoid, to a considerable extent, the long period during which the ware in the top of the kiln is exposed to the higher heat with the result that the amount of too hard-fired ware would be decreased. The reverse would, of course, hold for the ware in the bottom of the kiln. By regulating the admission of air through the furnace door and two openings, one immediately above the burners and one leading to the bag, it is possible to regulate the flow of the hot gases to the center of the kiln to some extent. But usually the main object of many firemen is to reach a safe maximum temperature on top and to hold it until the heat soaks down. It would be better to work the heat to the center as early as possible so as to maintain a smaller temperature difference between the two extremes.

Excess Air.—It is a curious fact that the heat penetration to the center is brought about more readily with coal than with natural gas. As the firemen say the bisque fires more "solid" with the former fuel than with the latter. Natural gas is by no means an easy fuel to use from the standpoint of complete combustion. Its high requirement of oxygen is difficult to meet when the heat is being raised fast and large volumes of the gas are introduced. This has been shown by gas analyses made by us, the results of which are given in the following table:

[1] *Proceedings Manchester Lit. and Philosoph. Soc.* (1874).

Time, in hours	3	6	9	10	13	18	20	22	23
Per cent air	336	220	190	222	129	102	108	104	114

Time, in hours	28	30	32	36	40	45	49
Per cent air	194	180	146	158	158	230	209

Here the values for the per cent of air given stand for the total percentage of air admitted, 100% being the normal amount for complete combustion. The figure 336 hence represents an excess of air of 226. As a matter of fact any value below approximately 125% represents reducing conditions, since it is inconceivable that the mixture of gas and air is so complete with the ordinary mushroom burner that complete combustion can take place with the theoretical amount of air. This is substantiated by the fact that carbon monoxide was always found with any total air percentage below 130–125. The above figures show then that there is incomplete combustion between the 12th and the 24th hour, that is during the period when the heat is being raised. This condition was overcome to a considerable extent by replacing the three burners used in each furnace mouth by five, with an equivalent of gas orifice area, thus increasing the proportion of primary air. Once carbon monoxide is formed the velocity of the gases is such that combustion of this gas becomes very problematical. During the soaking period the amount of air admitted becomes quite large in the effort to distribute the heat throughout the kiln.

Soaking.—The duration of the bisque fire is from 48 to 50 hours, of which from 12 to 18 hours may be spent in soaking. The glost firing consumes 28 hours of which about 6 hours are taken for soaking.

Means of Determining Heat Distribution

Absorption.—The question now arises as to what the real heat distribution of the updraft kiln is. This is ascertained for semi-vitreous ware by determining the absorption of the bisque ware taken from various parts of the kiln. Many surveys of this kind have been made by us and as a whole there are found decided differences in heat treatment. Citing a typical case in which 100 pieces of bisque taken from one kiln have been tested we find a minimum absorption of 3%, a maximum of 12.1 and an average of 8.2%. The mean minus variation is 2.5%, the mean plus variation 3.4% and the ± variation 5.9%.

Specific Gravity.—This reveals rather large differences in heat effect although it should be realized that absorption *per se*, is not a sensitive criterion of heat work accomplished. We have found that the density of the bisque is much more indicative of this and consider the body to have matured satisfactorily when its specific gravity has been reduced to 2.52 or below.

Heat Work Variations

A close study of the kiln conditions shows that there are well-defined areas which differ from each other decidedly with reference to the heat work done, in spite of the fact that the cones in the different quarters show practically no variation, as far as their usual positions are concerned. We find that there are throughout the kiln hot zones of comparatively small area alternating with cooler ones and that there are sections near the bottom of the kiln which are persistently yielding ware fired to a lower degree of maturity.

Streams of Hot Gases.—There are two conditions responsible for this. In the first place we must assume that there are in the kiln, currents or chimneys of hot gases and between these areas of lower temperatures. The updraft kiln as a whole functions like a chimney or stack and its upper portion is necessarily under a minus pressure. As the temperature rises the draft is increased more and more and with it the velocity of the gases. This induced draft causes the streams of hot gases which already have acquired considerable kinetic energy by issuing from the narrow bags, to follow the paths of least resistance and to produce well-defined currents. Such currents cannot be formed so readily in a downdraft kiln where the direction of the gases is completely reversed. We have hence at least eleven of such streams of gases, ten from the ten furnaces and one from the well hole. When coal is used as fuel these zones are less pronounced since the volume of gas produced is larger and meets with greater resistance in making its exit with the result that they fill the kiln space more completely thus tending to wipe out the differential currents.

Variation in Heat Absorption.—In the second place, the time-temperature relation of the various kiln sections differs quite decidedly so that the heat input shows corresponding variations. The outside ring and the top of the kiln obviously absorb more heat and at a higher temperature than the inner rings and the bottom.

Means of Obtaining Better Distribution

The question then arises as to how better distribution of temperature may be obtained. This may be accomplished in three ways.

Longer Soaking.—First, it may be done by a combination of firing in which the heat is driven toward the center earlier in the burn, the top is brought to a lower maximum temperature and the soaking period is lengthened by several hours. By maintaining a lower top temperature the tendency to overfire the ware is lessened and by lengthening the soaking period better distribution of the temperature is assured. Every hour of soaking at a safe temperature means an improvement in the condition of the kiln.

Draft Control.—Second, better control of the draft by means of properly designed dampers is a very desirable factor in the control of the heat distribution. The present methods used for this purpose are usually quite inadequate and fail to check the strong draft which obtains during the last stage of the firing which is responsible for much of the tendency to form the gas currents already referred to. Dampers such as have been designed by S. B. Larkins of the National China Company would do much to overcome this difficulty.

Forced Draft.—A third means of bringing about the desired heat distribution would be the use of a low pressure forced draft system, using an air pressure at the burners of not more than four ounces per square inch. Such a system is already being used by a number of plants and has been reported upon by Thomas B. Anderson of the Pope-Gosser China Co. in connection with the firing of natural gas. This system would mean the complete elimination of the minus pressure within the kiln and the substitution of a positive pressure. In other words, in such a system a large portion of the air required for combustion would be introduced as primary air in the burners, preferably pre-mixed with the gas. This would bring about several desirable conditions. The system would tend to bring about a much more uniform temperature heat distribution during the earlier periods of the firing and thus would shorten the soaking period very decidedly. This should result in a material reduction of hard-fired ware. Again the presence of a positive pressure within the entire kiln space would destroy the tendency toward the formation of the gas currents referred to since it is not possible to conceive of high and low pressure areas side by side when the pressure differences are of the magnitude obtained with the use of forced draft. As a result the gases would be forced to distribute themselves more uniformly throughout the kiln space and the firing should be expected to be more even in every way. Finally, the positive pressure maintained would effectively stop all leakage of air through the kiln walls and while it would result in higher outside wall temperatures the gain in efficiency would be noticeable. The total result hence should not only be a better distribution of temperature but a saving in fuel as well. The latter might be increased still more by the preheating of the air used for combustion in a recuperator which is neither a difficult nor expensive apparatus to install in connection with an updraft kiln.

It is the belief of the writer that forced draft at low pressure is one of the most effective means of obtaining uniform temperature conditions not only in the updraft but other types of kilns as well. At the same time such systems should make it possible to save time and fuel. The use of these firing methods is quite simple to carry out in connection with the use of natural gas and oil but becomes more difficult when coal is the fuel

used. While such systems have been applied to solid fuel with very good success and much credit is due the men who have designed apparatus of this kind still they are not as easy to control as might be desired. It is possible that the use of producer gas to which the air is supplied under pressure offers a solution of the difficulty.

HOMER-LAUGHLIN CHINA COMPANY
NEWELL, W. VA.

OPHTHALMIC GLASS—A NEW AMERICAN PRODUCT

By Robert J. Montgomery

ABSTRACT

Most of the ophthalmic or spectacle glass used in this country was imported prior to 1914. At present very little is imported and the industry is firmly established in the United States. The various glasses used are listed and their defects discussed. The problem of fusing bifocal lenses is covered in considerable detail. Marked improvement has been made in goggle glasses and colored glasses are being standardized. The effect of sunlight on certain clear and colored glasses is given.

Introduction

Definition.—Of the industries affected by the war little has appeared on glass used by the optometrist in spectacle lenses. Not only the clear colorless eye glass, but the various combinations used for fused bifocals, colored glasses, goggle glasses, etc., are of the group known as ophthalmic glass. This type of glass has been classed as optical because of the high precision required in its use, but it has very definite requirements which are quite different from those of optical glass.

History.—Prior to 1914, practically all the ophthalmic glass was obtained from Germany, France and England. It was chiefly blown glass,

Table I

	Name		N_D[1]	ν
1.	A clear crown		1.523	58.0
2.	A clear flint		1.616	36.5
3.	A clear flint		1.66	32.5
4.	A clear flint		1.69	31.0
5.	Goggle glasses		...	...
6.	Amber glass	3 shades	1.523	[2]
7.	Amethyst glass	2 shades	1.523	
8.	Blue glass	4 shades	1.523	
9.	Crookes glass	3 shades	1.523	
10.	Fieuzal glass	3 shades	1.523	
11.	Smoke glass	4 shades	1.523	
12.	Yellow glass	3 shades	1.523	

cut into round or oval discs the size of a lens ready to be reheated and pressed to the desired curvature. The supply of clear crown glass was quite uniform and satisfied the requirements of the manufacturer. The special glasses used in fused bifocal work and the colored glasses were, however, not satisfactory. The optical properties of these colored glasses would vary and colors could not be duplicated near enough to permit standardization of shades. For fused bifocals the manufacturing loss

[1] The optical properties referred to are the refraction index for the D line of the spectrum or N_D and the mean dispersion or ν obtained from the equation $\frac{N_D - 1}{N_F - N_C} = \nu$.

[2] The dispersion reciprocal for colored glass is usually about 58.0.

was usually great due to defective fusing of the two lenses. The fusing of the colored glass was practically impossible.

The war stopped importation. The clear crown glass, constituting probably 80 to 90% of the total was quite satisfactorily replaced by plate glass modified to raise the index of refraction to 1.5230. The special flint and colored glasses were not so readily produced, although during the past three years much progress has been made in providing a domestic supply of the flint and colored glasses.

Production in America.—America has developed glasses which equal the foreign glasses in all respects. The preceding list gives the more important of the ophthalmic glasses.

Any number of special colors have been introduced in addition to the above but these are the principal ones. A short discussion of each type will be given.

Clear Crown Glass

Manufacture.—Soda lime glass is rolled into a sheet $^1/_4$ to $^3/_8$ of an inch thick. This rough rolled (or polished) plate is cut into squares the size of the desired lens. It may be blown into cylinders and flattened but it is hard to make blown glass $^3/_8$ of an inch in thickness.

Freedom from Flaws.—Absolute freedom from bubbles, cords or striae which can be seen through the finished lens is necessary. Some striae is always found in rolled or blown glass but when it runs perpendicular to the line of vision and not too heavy it does not cause trouble. This point is discussed in detail by H. S. Roberts and J. C. Hostetter.[1]

Color.—Exposure to sunlight will noticeably change the color of practically all crown glass. A distinct straw tint develops in a few days. This tint will not increase materially after thirty days of continued exposure. The following absorption figures show the change in a commercial spectacle glass after thirty days' exposure.

ABSORPTION OF SPECTACLE GLASS

Wave length ($\mu\mu$) Color	640 Red	578 Yellow	546 Green	492 Blue-green	436 Blue
Before exposure	3.35%	2.19	0.32	2.77	1.29
After exposure	4.05%	2.01	3.47	6.78	13.51

This color change may be controlled to some extent and has been reduced materially so that after thirty days' exposure it can hardly be measured.

Expansion.—The coefficient of expansion is important. It must be under control as the glass must allow of fusion with the flint glasses without undue strain. A more detailed discussion of this will be given under flint glasses.

[1] *Jour. Amer. Ceram. Soc.*, **3** [9], 750 (1920).

Flint Glasses

Use.—Three flint or lead glasses are largely used for kryptok bifocal lenses, to allow of far and near vision through different portions of the same lens. A small disc of flint glass, curved on one side, is fused on to the crown glass. The difference in index of refraction of the two glasses gives the desired optical effect. The three flint glasses usually used are of increasing lead content having indices of refraction of 1.616, 1.66 and 1.69 as compared with 1.523 for the crown glass.

Fusion of Bifocal Lenses.—The fusing together of two glasses is a delicate operation at best. The fusion of a spectacle lens must be optically perfect. This means that both parts of the finished piece must be practically free from strain and that no fog, bubbles, mechanical dirt or cracks must appear at the surface of contact. The exterior surfaces are ground and polished after the fusion, but the surface of contact between the glasses is beyond reach. The curve on the crown glass must be maintained. The contact surfaces must be free from defects.

Physical Properties and Defects in Fused Bifocal Lenses

Strain.—The flint and crown glasses must so match in expansion that on cooling after fusion the lens will be well annealed and show the least possible strain in polarized light. Fusions of this kind are quite simple when the glasses are of the same general composition and fusibility. The fusion of a hard soda-lime glass with a soft flint glass, free from strain, is practically impossible when both have the same coefficient of expansion, as this property is usually determined. The compatibility of two glasses for bifocal purposes cannot be determined by drawing to a thin thread, two pieces fused together, as suggested by Donald E. Sharp[1] and judging the relative expansion by the bend of the thread. We have never been able to fuse together a crown and a flint glass without excessive strain which matched or showed no bend in this drawing test.

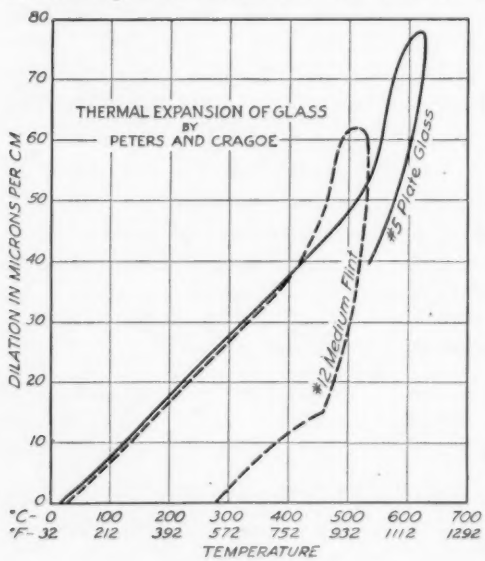


FIG. 1.

[1] *Jour. Amer. Ceram. Soc.*, **4** [3], 219 (1921).

The expansion of all the glasses tested by Peters and Cragoe[1] was very regular during the first 350° to 500°C. Above this temperature the samples expanded at an increased rate during the next 100° rise. Then a rapid decrease in the rate took place as the glass softened, until finally a contraction was obtained. Figure 1 shows the expansion curves of a plate glass No. 5 and a medium flint No. 12 as given by Peters and Cragoe. These compare closely with the crown and the flint of 1.616 index of refraction used by optometrists.

The temperature for fusing bifocal lenses is 600 to 700°C or at a point where the crown glass becomes fairly soft and the flint glass has reached the deformation or contraction stage. The contraction on cooling is complicated by factors other than the coefficient of expansion.

The two other flints with an index of refraction of 1.66 and 1.69 are still higher in lead content and soften at still lower temperatures giving a greater difference between the expansion curves of the crown and the flint.

W. B. Pietenpol[2] has shown that the quality of the annealing will affect the expansion especially during that period just before the expansion rate increases rapidly. On the reheating and cooling of a strained strip of glass, a definite shortening was obtained proportional to the strain which had been released. This is found in practice when reannealing badly strained fusions. Arthur W. Gray[3] also noticed a failure of the glass to return to its original length after strong heating.

From the above it will be seen that the strain problem is far from being a simple one.

Fog.—A common defect to be found when a crown and a flint are fused together is a surface devitrification. This probably is due to crystals of cristobalite, and is called fog in the factory as it appears as a cloudy surface between the two glasses. It is often very hard to detect and special illumination is usually necessary to show these fine crystals.

There is a decided tendency for flint glass to devitrify. C. N. Fenner and J. B. Ferguson[4] report devitrification in a light flint glass. They found that chlorides and sulphates cause milkiness due to the formation of crystals of cristobalite. Bowen[5] gives a rather detailed discussion of the conditions which control crystallization in glass. He found that a medium flint glass shows a surface film at 650°C and an ordinary crown glass shows a surface film at 700°C. Amenomiya[6] found that crystallization appeared

[1] C. G. Peters and C. H. Cragoe, Jr., "Thermal Dilation of Glass at High Temperatures," *Op. Soc. of Amer.*, **4**, 105 (1920).

[2] *Chem. and Met. Eng.*, **23**, 876 (1920).

[3] *Ibid.*, **21**, 667 (1919).

[4] *Jour. Amer. Ceram. Soc.*, **1** [7], 468 (1918).

[5] *Ibid.*, **2** [4], 261 (1919).

[6] *Jour. Soc. Glass Tech.*, **6**, 231 (1922).

at 700°C and above on ordinary plate glass.

The process of fusing kryptok bifocals is ideal for the development of crystals. The glass is heated to the softening point and held for a considerable period. By careful control of the composition the tendency to devitrify can be decreased and we have found it thus possible practically to eliminate this defect.

In general we have experienced more trouble from fog with the flint glass having an index of refraction of 1.616 than with the ones containing higher per cents of lead. However, with the imported glasses we have had much trouble, all three flints giving surface fog. As the fog is between the flint and the crown it cannot be removed during the final grinding and polishing of the lens.

Bubbles.—When two lenses are fused together gas is often entrapped between the pieces of glass. The resulting bubbles make the finished lens useless. Fortunately losses from this cause are not very large. It is doubtful if the trouble from bubbles can be entirely eliminated.

Perfect cleaning of the glass before fusion and freedom from dust will reduce the loss from bubbles but gas may come from the glass itself at the fusion temperatures and be unavoidably held between the two lenses as the fusion takes place.

We know that a large amount of gas is held in solution in a glass. Cullet will boil almost as much as will a new batch showing that considerable gas is being evolved. Washburn and Bunting[1] actually made an analysis of the dissolved gases which are given off at 1400°C under reduced pressure and found them to be oxygen, carbon dioxide and nitrogen. It is not only at the melting temperature that gas will be evolved. Irving Langmuir[2] reports that on heating glass to 300°C water vapor is given off. This is progressive, giving increasing amounts up to 450°C. Carbon dioxide and nitrogen were found in another test at 300°C.

It is not unreasonable to assume that gas is given off continuously in increasing amounts as the temperature is increased from 300°C to 600° or 700°C, the temperature at which glasses are fused together. It would be difficult not to entrap some of this gas as the two glasses are fused.

The other defects appearing in bifocal lenses using the three flint glasses are largely mechanical in nature and will not be discussed here.

Goggle Glasses

A goggle glass is one which will give protection to the eye of the workman and must stand ordinary impact without breaking. Two types are on the market. The first is composed of two layers of glass with a film of celluloid or similar material between. A sheet of celluloid is interposed be-

[1] Univ. of Ill. Eng. Expt. Sta., *Bull.* **118** (1921).

[2] *Jour. Amer. Chem. Soc.*, **40**, 1361–1402 (1918).

tween two sheets of glass, treated with a softener (such as industrial spirits) which causes it to adhere to the glass by the simultaneous action of heat and pressure.[1] A lens of this style was tested, using the method suggested by the Bureau of Standards, by dropping a steel ball 1.59 cm. in diameter a distance of 54 cm. onto the center of the lens. Although it cracked with the first impact, the glass did not give way or fall apart and would have protected the eye.

Owing to the thickness of the double lens and the color of the celluloid the light transmission of the glass is considerably reduced. This is objectionable.

The second method is to take the ordinary lens and harden it by a sudden uniform cooling. This introduces a uniform strain in the glass, making it very tough. It will not break so easily as the celluloid type of lens but when it does crack it does not hold together so well. This idea of hardening was used as early as 1874 by Alfred De La Baste[2] and has been applied to lamp chimneys and high pressure gage tubes.

A special glass has now been developed which will stand much more than the ordinary laminated or hardened lens and while more expensive is well worth it. A Bureau of Standards test on lenses made from this special glass shows that, when properly finished, they will stand a blow ten times as great as the ordinary goggle lens.

Practically all goggles are of flat glass without curve so the optical properties are unimportant. The index of refraction is usually about the same as that of the regular crown or about 1.523.

Colored Glass

Items 6 to 12 inclusive of Table I give the common colored glasses used by the optometrist. There are many special ones on the market. These trade names mean in a very general way, certain colors and shades but there are no recognized standards. The Bureau of Standards have determined and published the absorption curves for many of these glasses.[3] Much of the glass used has been imported and the color and optical properties would vary greatly from shipment to shipment or even in the same shipment. Almost every lens manufacturer has a different source of supply so each have a series of colors which only match those of other plants in a very general way. The color varies with the thickness of the lens and it has been found necessary to obtain the same color in glass of at least three thicknesses to give satisfactory control of the shade. Thus Smoke A shade requires three glasses having shade A color at 2, 4 and 6 mm. in thickness.

[1] *Chem. Abs.*, **12,** 986 (1918).

[2] British patent 2783 of **1874,** class 56.

[3] Gibson and McNicholas, "The Ultra Violet and Visible Transmission of Eye Protection Glasses," Bur. Standards, *Tech. Paper* **119.**

It is quite desirable to make fused bifocal lenses using the various colored glasses for the crown part of the lens. Very few combinations are successfully fused at present. Some progress has been made on this and we hope that before long a complete line of colored glasses will be placed on the market for kryptok fusions.

The most popular color just now is the Crookes glass which is made in three or four shades. It has the property of absorbing a considerable part of the ultra-violet light and has two absorption bands in the yellow at the *D* line of the spectrum.

There seems to be no general agreement among optometrists as to just when each color and shade should be prescribed. The subject is being studied. Now that the glass maker and user are coöperating rapid progress should be made.

Next to the Crookes glass in popularity comes the smokes and ambers. The fieuzals, amethysts and blues are used considerably. Special shades and colors are often used for furnace work, electric welding, etc.

When colored glass is exposed to sunlight for a considerable period there is often a noticeable color change. The following absorption figures are for a sample of commercial amber glass, shade A, before and after being exposed to sunlight for thirty days.

AMBER GLASS SHADE A

Wave length ($\mu\mu$) Color	640 Red	578 Yellow	546 Green	492 Blue-green	436 Blue
Before exposure	11.71%	12.79	14.29	23.87	46.87
After exposure	14.79%	16.59	18.59	30.55	51.38

The change of color was largely a darkening of the shade as judged by the eye. The color change in amethyst glass made with manganese is well known. The absorption figures given are for a sample of amethyst shade B glass which turned quite blue on exposure to the sun for 30 days.

AMETHYST GLASS SHADE B

Wave length ($\mu\mu$) Color	640 Red	578 Yellow	546 Green	492 Blue-green	436 Blue
Before exposure	17.55%	30.73	33.59	37.35	23.32
After exposure	20.70%	33.26	34.53	35.99	21.41

The color change to the eye is greater than would be expected from the difference in absorption.

The smoke and the Crookes glasses usually change color. The fieuzal and the blue are the most stable of those we have tested.

This changing in tint makes it practically impossible to match many colored glasses after they have been worn for a time and an effort is being made to stabilize the colors as much as possible. As was shown in the

first part of this paper the clear glass usually changes tint on exposure to the sun. This change in the base glass would naturally change the tint of a colored glass even if the added coloring material itself remained unchanged. There are several colors that will be very stable if a base glass is used which will not change tint to any extent when exposed to sunlight.

Very little of the ophthalmic glass now used in the United States is imported and in many respects this new industry has already progressed beyond the point reached in Europe.

BAUSCH AND LOMB OPTICAL CO.
ROCHESTER, N. Y.

EFFECT OF VARIOUS SIZES OF GROG PARTICLES ON CLAY POTS

By Warren S. Williams

ABSTRACT

The service obtained from refractory clay, glass-drawing pots, 40 inches in diameter, was increased in factory practice by eliminating grog particles finer than 40-mesh.

Introduction

In the manufacture of window glass, by the cylinder drawing machine process, molten glass is ladled from a tank into a refractory clay pot, such as shown in Fig. 1.

These pots are rotatably mounted in a heated draw-kiln by iron pins inserted into the lugs. This design permits a cylinder of glass to be drawn upward out of the top side of the pot, while the excess glass from the previous draw is melted away by heat on the bottom side. The top is cooled, during the draw, from approximately 2200°F to 1700°F in twenty minutes. At the same time, the bottom is heated over the same temperature range by two diametrically opposite burners in the draw-kiln using natural gas and pressure air. The flames meet and impinge upon the center of the pot and then spread over its bottom surface. This process is repeated continuously for twenty-four hours a day. On Sunday the pots are left in the draw-kilns and are covered with iron covers, under which they are reversed every twenty minutes. The temperature drop during this period is from approximately 1700°F to 1200°F.

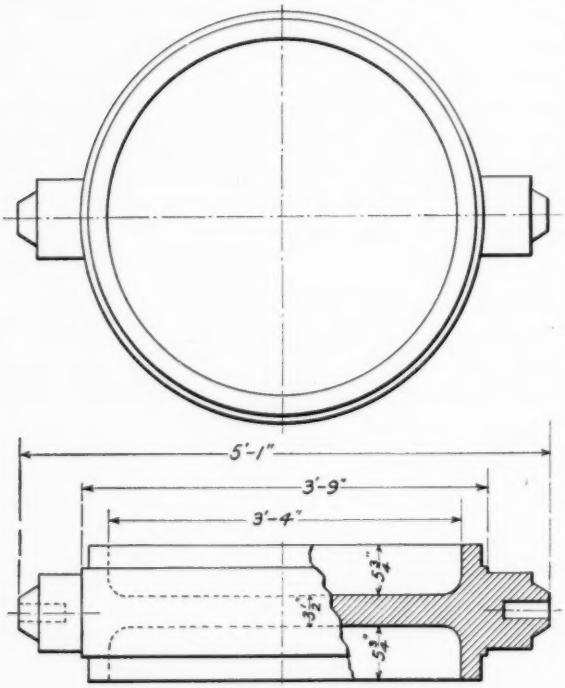


Fig. 1.—Glass drawing pot.

Pot Manufacture

The refractory clay batch for the pots is prepared by mixing the ground materials dry and then shoveling the batch directly into the hopper of an

auger brick machine. In this machine the batch is mixed with water and receives a slight pugging. It is re-pugged several times by the same machine during the aging period.

The pot is built by hand over wooden cores, and weighs approximately 800 pounds when dry. After drying it is burnt in a kiln with a capacity of ten or more pots. When the burn is finished the temperature is dropped to 1800°F. At this heat the pots are transferred to the draw-kilns. Within a few minutes after reaching the draw-kilns a ladle of molten glass, weighing approximately 700 pounds, is poured into them and the drawing operation is started.

Experimental

The service rendered by the pots is reckoned in the number of days in operation in the draw-kilns. During an investigation into methods of increasing this service, experiments were started demonstrating the effect of the size of the grog particle. The batches for this research were made full size in the standard factory manner as previously described. The only variable introduced was the difference in the size of the potshell (grog) particles as given in Table I. Potshell is obtained by chipping the glass away from old pots which have been removed from service. It is 50% by weight of the total batch. The pots made from these batches were full size (Fig. 1) and were manufactured, burned and used in the same manner as standard pots.

The data in Table I was selected from those pots removed from service through failure directly traceable to the clay body, as distinguished from failures due to mechanical operations in the draw-kilns.

TABLE I

	Size of potshell particles					Pot service	
	Percentage retained on			Through	Total pots	Total days	Average days
Size no.	10-mesh	20-mesh	40-mesh	40-mesh	used	in service	in service
1	18	29	28	25	86	1639	19
2	21	26	24	29	54	1112	21
3	5	36	30	29	29	639	22
4	66	24	8	2	28	778	28

Results

Those pots made with a greater percentage of finely ground potshell failed largely through knuckle cracks, rim cracks and splitting into halves. These defects were eliminated in a higher percentage of the pots made from the coarser ground batches.

Under comparable conditions as met in large scale factory practice, the practical elimination of grog particles finer than 40-mesh has resulted in increased service from refractory clay, glass-drawing pots.

ARNOLD, PA.

AN INVESTIGATION CONCERNING THE INFLUENCE OF THE ALKALIES AND ALKALINE EARTHS ON THE FUSION TEMPERATURES OF THE DIFFERENT TYPES OF REFRACTORY CLAYS

By A. S. Watts[1]

ABSTRACT

A summary of results of an investigation regarding the application of Richter's law and its modifications to refractory clays of higher and lower alumina and silica content than previously studied.

The following article consists of a brief summary of conclusions reached by A. L. Donnenwirth, R. S. Kane and E. R. Curry, Ceramic Engineers, 1922, in a study based on Richter's Law "Equal molecular amounts of basic fluxes have the same effect on clays or kaolins and that the greater the silica content the more effective are the fluxes."—(1868).

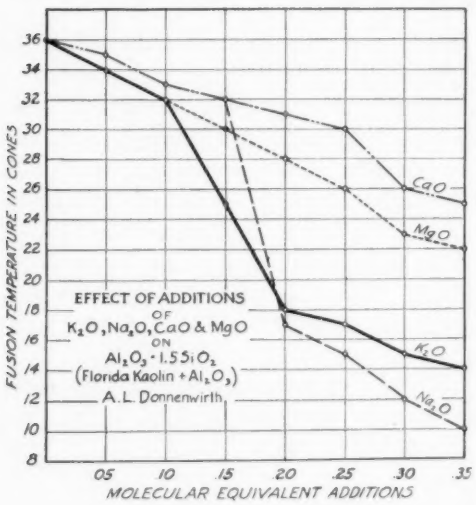


Fig. 1.

Twenty years after Richter, Cramer using Zettlitz kaolin concluded that the effect of the basic fluxes was not widely different when a pure kaolin ($Al_2O_3 - 2SiO_2$) was used but when one-half molecule silica was added ($Al_2O_3 - 2.5SiO_2$) the activity of the flux increased as the molecular weight decreased. The activity was not exactly in inverse ratio of their molecular weights.

Rieke conducted additional investigations with other bases and also checked Cramer's conclusions (*Sprech.*, 198–9, 214–6, 229–32 (1910)).

Montgomery and Fulton,[2] concluded that with 14 to 18% Al_2O_3 and 86 to 82% SiO_2, the fluxes display maximum activity.

The Present Investigations

Table I

The clay tested was Florida kaolin and its analysis was:

Ignition loss 14.86%; SiO_2 45.67%; Al_2O_3 38.45%; Fe_2O_3 0.75%; TiO_2 0.10%; CaO trace; MgO 0.05%; KNaO 0.06%.

Proportion of Alkalies:

One equivalent of this clay was ground with one equivalent of K_2CO_3 and with Na_2CO_3 in enough benzol to permit molding into balls. The

[1] Presented before the Refractories Division, Pittsburgh Meeting, Feb., 1923.

[2] *Trans. Amer. Ceram. Soc.*, **19**, 303 (1917).

balls were calcined to cone 10. (Seger and Cramer found that subsequent fusions after a cone 10 calcine do not lose over 0.56% alkali.) The clay alkali mixtures were then analyzed with the following results:

TABLE II

	Florida Kaolin Theoretical per cent	Flux Calcine Actual content per cent
K_2O	29.61	21.24
Na_2O	21.79	16.55

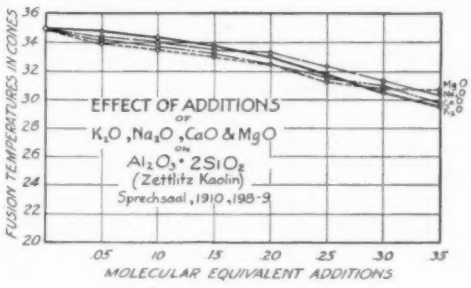


FIG. 2.

The alkaline earths were added directly as $CaCO_3$ and $MgCO_3$. The calcines were next ground with the proper proportions of the raw clay to give the desired compositions, the excess Al_2O_3 or SiO_2 being added to the grind as such.

These mixtures were made into standard size cones and tested against standard cones in an air-gas furnace. The results follow.

The Compositions of Clays Studied

Al_2O_3 1.5 SiO_2; Al_2O_3 3.0 SiO_2; Al_2O_3 5.0 SiO_2.

From a study of the graphs presented, we see:

(1) When the Al_2O_3 exceeds the proportion in the true kaolin formula, the order of activity increases from MgO to CaO to Na_2O to K_2O.

(2) When the SiO_2 exceeds the proportion in the true kaolin formula, the order of activity is reversed and decreases from MgO to CaO to Na_2O to K_2O.

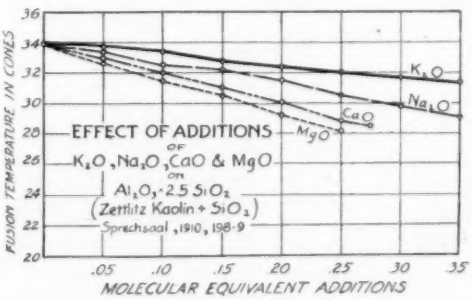


FIG. 3.

(3) As the SiO_2 increases the activity is increasingly evident.

(4) The increase of activity with increased amounts of fluxes is more pronounced when the Al_2O_3 is in excess than when the SiO_2 is in excess. The presence of moderate amounts of fluxes is more dangerous in high aluminous clays than in high siliceous clays.

Discussion

J. S. McDOWELL (Chairman):—At high temperatures silica is so viscous that it has been extremely difficult to determine its melting point. This is now known to be about 1710°C. However, a comparatively pure quartzite will go down at cone 36, corresponding to about 1775°C, which gives a range of viscosity of 65° for pure silica. On the other hand, a certain

mixture of silica with a few per cent of lime or alumina, has a true melting point of 1610°, while the softening point is 1615°, practically the same effect may possibly be brought about by lime and magnesia additions to clays.

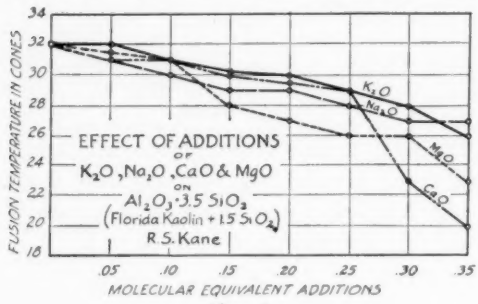


FIG. 4.

W. A. HULL:—I think it might be worth while to state that the results obtained by investigators who have been studying the reactions between lime, alumina, and silica at high temperatures in connection with work on cements has lead to the conclusion that lime is a much more active flux with alumina than with silica at high temperature, which corresponds, as I understand it, to these results. That would check up with the fact that the lime reacts very readily with the high alumina refractory. P. H. Bates has called attention to the fact that while lime is active with alumina and therefore high alumina brick will not show up well in a high temperature test with lime, yet the high alumina brick actually give the better service in rotary cement kilns. He attributes this apparent discrepancy to the fact that lime, with the free silica in more highly siliceous fire brick, forms the dicalcium silicate, $2CaOSiO_2$, which dusts at 200°C. He attributes the failure of the rotary kiln brick that are higher in silica to disintegration due to dusting of $2CaOSiO_2$.

A MEMBER:—Is the alkali more active than the alkaline earth?

B. WILCOX:—We always find that the alkaline fluxes are more active.

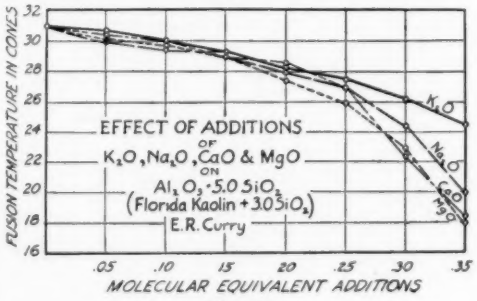


FIG. 5.

G. V. MCCAULEY:—We have noticed a phenomenon in connection with our Pyrex tanks which has some bearing on this question. The temperatures which we have to run in these tanks are so high that considerable volatilization of soda takes place. As this vapor passes through the checkers with the out-going gas the top of the checker pile is too hot for these vapors to condense; but down near the bottom of the pile these vapors do condense and attack the checker brick at this point. When one of these tanks is let out one finds the bottom checker brick almost gone. By substituting silica for fire-clay brick in the checkers this attack was lessened to some extent.

THE FLINT CLAY SITUATION IN OHIO[1]

By Wilbur Stout

ABSTRACT

A discussion of the flint clays of Ohio with special reference to Sciotoville, Lower Kittanning, Oak Hill and Lower Freeport clays. It is shown that (1) flint clay beds of high heat duty quality in Ohio are small but well-defined (2) there is small prospect of finding other deposits under deeper covering (3) the most easily available material is exhausted (4) the present supply will last present plants at least fifty years but will not permit much increased consumption (5) conservation of high heat duty clays should begin now before supply is gone.

Introduction

The flint clays in Ohio are confined to the Pottsville, Allegheny, and lower Conemaugh formations or to that part of the Pennsylvanian system, the rocks of which are largely of marine origin. Deposits economically important are found only in the Pottsville and Allegheny formations as those in the Conemaugh are uncertain in extent and thickness and poor in quality. Both the flint and plastic clays are directly associated with the coal beds or they mark horizons on which coals elsewhere occur. In the Ohio field in small or large quantities flint clay occurs below the Sharon, Anthony, Flint Ridge, Upper Mercer, Bedford, Brookville, Winters, Clarion, Lower Kittanning, Oak Hill, Lower Freeport, Upper Freeport, Mahoning, Mason, and Harlem coals. Of these, however, the only deposits that are sufficiently large in area and have qualities recommending their use for high heat duty refractory ware are found below the Anthony, Lower Kittanning, Oak Hill, and Lower Freeport coals. These members will be considered in regular order beginning with the oldest.

Sciotoville Clay

The Sciotoville clay is the second well-recognized clay stratum in the Pottsville formation. It lies on the average from twenty to forty feet above the Sharon coal and approximately the same distance below the Quakertown bed. It is directly overlain by a coal which is known as the Anthony but which seldom attains a thickness exceeding one foot. In Ohio, the Sciotoville clay of the characteristic flinty quality is confined largely to two districts which are known as the Sciotoville and the Logan from their proximity to these places. Small outlying patches of flint clay, however, are present in parts of Jackson, Pike, and Vinton Counties.

The Sciotoville clay is not a persistent bed by any means even in the areas in which it is best developed. It is wanting, however, more through lack of deposition than through removal by erosive agencies subsequent

[1] Presented before Refractories Division, Pittsburgh Meeting, Feb., 1923.

to its formation. It appears to have been formed in swamps which were more or less isolated and which were irregular in outline. It is wanting also over large areas due to the fact that the lower Pottsville members were deposited only in the low troughs and basins in the uneven Mississippian floor. Due to these causes the fields of Sciotoville clay are usually small and the deposits within the areas are irregular and uncertain.

In the Southern Ohio or Sciotoville field the average thickness of the flint clay in the productive areas is from 2 feet 6 inches to 3 feet and the semi-flint clay has much the same measurement. The combined thickness is usually between 3 and 7 feet with a maximum of about 12 feet.

Scioto County.—In a general way, the Sciotoville clay is confined to the eastern half of Scioto County but owing to wants through lack of deposition and through loss by erosion it covers only a small part of this area, in fact, the total known field is not more than thirty square miles in extent. The most continuous bodies of flint clay are found in western Harrison and eastern Bloom townships. In the remainder of the county the deposits are more or less isolated and are usually small, only a few acres in extent.

The western part of the Sciotoville field or that lying between the Scioto and the Little Scioto rivers has been so exhausted by mining for the original plants at Sciotoville and Portsmouth that it is now practically abandoned. Not more than 50% of the clay, however, was removed, for the deposits lay so near the summits of the ridges that the roof was poor. As the flint clay in this area is of excellent quality and as the covering is thin, parts may be mined in the future, when such materials become scarce, by steam shovels. At most the quantity of clay that may thus be recovered would be sufficient only for supplying two or three brick plants for approximately forty years. The cost of such material would be high owing to unprofitable stripping part of the time over old mines and to the expense of transportation which would be by motor trucks. The conditions at best are unfavorable and will not warrant the establishment of new plants. It will probably remain abandoned, as it is at present.

The known area of Sciotoville clay east of the Little Scioto River is less than ten square miles in extent and has been drawn upon since 1870 for high heat duty refractory material. It supplied clay for plants, now abandoned, at South Webster and Sciotoville, and furnishes material at present for two works at Oak Hill, one at Scioto Furnace and two at Portsmouth. The productive area is largely controlled by the present firms whose supplies of material are ample to meet their needs for many years. The blocks of clay not controlled, however, are generally too scattered

or too small to justify the erection of new works. Possibly two or three new plants could be maintained but not more than this. Of the scattered deposits of Sciotoville clay in northern Scioto, western Jackson, eastern Pike, and southern Vinton Counties little need be said as most of them are only a few acres in extent and far removed from lines of transportation. Only two of them are worthy of prospecting for such purposes.

It is thus seen that in the Sciotoville clay field of southern Ohio the supplies of material yet available would not justify the establishment of more than five new plants. It is, in fact, at its maximum and will not be able to take care of increased business in the future.

The flint clay of the Sciotoville field is well within the high heat duty class of refractory materials and is rather constant throughout the field in both composition and physical properties. Typical examples are given in Table I.

TABLE I

CHEMICAL COMPOSITION

	Per cent	Per cent		Per cent	Per cent
Loss at 105°C	1.35	1.62	P_2O_5	0.02	0.11
Ignition loss	12.90	12.76	Na_2O	.00	.62
SiO_2	45.20	45.13	K_2O	.52	.76
Al_2O_3	36.77	34.08	MnO	trace	.01
Fe_2O_3	1.30	2.35	S	trace	.17
CaO	0.50	0.25	Total C	0.25	.52
MgO	.08	.54	Inorganic C	.03	.00
TiO_2	1.80	2.08			
Oxide ratio	RO 0.062 Al_2O_3 1.00	SiO_2 1.279		RO 0.127 Al_2O_3 1.00	SiO_2 1.368
Total linear shrinkage at cone 14	10.47			9.65	
Deformation temperature cone 33				32½	

Hocking and Perry Counties.—In the vicinity of Logan in Hocking and near Maxville in Perry County, the Sciotoville member is somewhat persistent in an area of a few square miles but in this flint clay is found only in isolated pockets. Upon these, however, brick works were established at Logan in 1874 and operated for refractory ware until 1890. Flint clay was also shipped from this district to Columbus for the manufacture of similar products. In this small field the average thickness of good flint clay is about two feet and the maximum measurement not more than four feet. The flint clay is often underlain by several feet of semiflint or "pink eye" of poor quality. Under present conditions these deposits do not warrant the establishment of plants and at best they could support but a small industry. The flint clay is generally of fair quality as shown in Table II, a representative test:

TABLE II

CHEMICAL COMPOSITION

	Per cent		Per cent
Loss at 105°C	1.15	P_2O_5	0.02
Ignition loss	10.53	Na_2O	trace
SiO_2	52.58	K_2O	0.66
Al_2O_3	30.45	MnO	.02
Fe_2O_3	1.91	S	.02
CaO	0.26	Total	.15
MgO	.19	Inorganic C	.02
TiO_2	1.94		
Oxide ratio	RO 0.094	Al_2O_3 1.00	SiO_2 1.791
Total linear shrinkage at cone 14	6.93		
Deformation temperature	cone $31\frac{1}{2}$		

Lower Kittanning Clay

The Lower Kittanning clay, found just below the Lower Kittanning or No. 5 coal, is very persistent across the State as it extends with few wants from Lawrence County on the south to Columbiana County on the east. The position of the clay with reference to other well known members is, on the average, about twenty-two feet above the Vanport limestone and nearly thirty-five feet below the Middle Kittanning or No. 6 coal. The clay ranges in thickness from two to twenty feet and the overlying coal from a mere soot streak to six feet.

In most of the Ohio field only plastic clay is found on the Lower Kittanning horizon but in local areas flint clay is also present in small or large quantities. The largest and really the only important field of flint clay on this horizon in Ohio is in Sandy, Lawrence, Dover, and Franklin Townships in northern Tuscarawas County and in Rose Township in western Carroll County, the combined area of which is about fifty square miles. Owing to the position of the member high up on the hills and to the many wants, the actual area of flint clay is not in excess of ten square miles. Further, a part of this has been exhausted by mining. In this field the flint clay is bedded within plastic clay. In ascending order the succession is, on the average, 3 to 5 feet of plastic clay, 3 to 4 feet of flint clay, 3 to 5 feet plastic clay and 2 to 3 feet Lower Kittanning coal. The flint clay varies from 1 to 10 feet in thickness and is somewhat patchy in development. Of the plastic clays the one below the flint clay has the best properties and is the one used most largely for bonding purposes.

The flint clay in the Strasburg field was first used for refractory products in 1865 when a small plant was built by David Miller and Company at Dover. Other plants were then gradually erected so that at present eight works are in active operation in the district.

The largest supply of flint clay of good quality in Ohio is present in this

area. At that the total combined areas of undeveloped material appears to be not more than seven square miles, which is sufficient to take care of the needs of the present plants for some forty years and to provide for probably an equal number of new ones. Under such conditions, however, the field would be nearing exhaustion in fifty years or less.

The character of the flint clay in the Strasburg field is shown by the tests given in Table III.

TABLE III

CHEMICAL ANALYSIS

	Per cent	Per cent		Per cent	Per cent
Loss at 105°C	2.15	1.85	P_2O_5	0.03	0.19
Ignition loss	11.29	11.78	Na_2O	.00	.04
SiO_2	52.31	51.13	K_2O	.34	.05
Al_2O_3	29.52	30.44	MnO	trace	trace
Fe_2O_3	2.85	2.00	S	0.84	0.95
CaO	0.25	0.38	Total C	.26	.22
MgO	.06	.64	Inorganic C	.03	.01
TiO_2	1.45	1.80			
Oxide ratio	RO 0.109	Al_2O_3 1.00	SiO_2 1.822	RO 0.096	Al_2O_3 1.00	SiO_2 1.745
Total linear shrinkage, cone 14	7.01			9.23	
Deformation temperature, cone	$32^1/_2$			$32^1/_2$	

Oak Hill Clay

The Oak Hill clay holds distinctive features from northern Lawrence to southern Coshocton Counties and may be identified in an impoverished condition in Stark and Columbiana Counties. It is found in the interval between the Lower Kittanning and the Middle Kittanning coals but in most places it lies much nearer the former than the latter. Although the field is large the clay occupies only a small part of this for it was deposited in isolated basins some of which are small in extent and widely spaced. Further, in most of the field the clay is impure, being so contaminated with iron oxides and calcareous matter that it falls below the class of high heat duty refractory materials. It holds the best properties and the best mining conditions in Jackson County and especially in a small area of a few square miles near Oak Hill. In this district the Oak Hill clay lies directly above the Lower Kittanning coal so that flint clay, plastic clay, and coal may all be taken from the same entry. Northward from this place shale varying from five to twenty feet in thickness intervenes between the coal and the clay which means that the beds would have to be mined separately.

The average thickness of the Oak Hill member is about three feet of which nearly one-half is flint clay of good quality and the other half plastic or semiflint clay with inferior properties. The maximum thickness of the flint clay is about three feet and that for the entire member ten feet.

The Oak Hill clay first attracted attention in 1873 when plants were built by the Aetna Fire Brick Company and by the Oak Hill Fire Brick Company. At present it is the main raw material used in four plants and is employed to a small extent in two more.

The quantity of Oak Hill clay in this small field yet available and with conditions favorable for drift mining is only ample to take care of the needs of the present plants. New operations are not justified. In the central and northern parts of the county where the clay lies several feet above the Lower Kittanning coal, the cost of mining would be prohibitive under the present status of the industry. In the remainder of the field in Ohio, that is, in Vinton, Hocking, Perry, Muskingum, Coshocton, and Columbiana Counties, the Oak Hill clay is too impure for high grade refractory products.

The quality of the Oak Hill clay in Jackson County is shown by the tests given in Table IV.

TABLE IV

CHEMICAL ANALYSIS

	Per cent	Per cent		Per cent	Per cent
Loss at 105°C	2.47	2.05	P_2O_5	0.11	0.24
Ignition loss	10.72	11.96	Na_2O	.10	.34
SiO_2	53.73	50.13	K_2O	.17	.14
Al_2O_3	29.63	32.00	MnO	.01	trace
Fe_2O_3	1.76	1.16	S	.09	0.06
CaO	0.21	0.14	Total C	.22	.11
MgO	.32	.08	Inorganic C	.20	.06
TiO_2	1.10	1.75			
Oxide ratio	RO 0.081 Al_2O_3 1.00	SiO_2 1.854		RO 0.055 Al_2O_3 1.00	SiO_2 1.629
Total linear shrinkage, cone 15	5.34			7.45	
Deformation temperature, cone 32				32	

Lower Freeport Clay

The Lower Freeport clay adds but little to the ceramic resources of Ohio as, in a broad sense, the bed lacks continuity in the greater part of the field and as the material with few exceptions fails to meet the requirements for the manufacture of high heat duty refractory ware. It is of most value in a small area near Moxahala in Perry County where the member yields a flint clay of fair quality. The usual position of the Lower Freeport clay is about midway in the interval between the Middle Kittanning and Upper Freeport coals which are the best benches for reference and which are separated by about ninety feet of strata. More specifically, the Lower Freeport clay lies below the Lower Freeport limestone or where this is absent below the Lower Freeport coal. The common argillaceous material on the Lower Freeport horizon is plastic clay in which, locally, lenses and irregular masses of flint clay are interbedded. Such deposits

are uncertain in extent and generally quite variable in quality. Near Moxahala such deposits are irregularly distributed in Sections 30, 24, 19, and 20, Pleasant Township, and Section 17, Bearfield Township. In this district the member is made up of flint or plastic clay or both and has a thickness ranging from three to twenty-five feet. Part of the material in most places, however, is of poor quality. The quantity of clay in this locality is sufficient to last a few plants for many years. The chief objection is the uncertainty of the deposits and the frequent contamination by ferruginous and calcareous matter. At present the field furnishes clay for two plants and may never provide for more than this number. The tests given in Table V were made on representative material used for clay products.

TABLE V

CHEMICAL ANALYSIS

	Per cent		Per cent
Loss at 105°C	1.65	P_2O_5	0.02
Ignition loss	9.05	Na_2O	.19
SiO_2	59.71	K_2O	1.20
Al_2O_3	24.58	MnO	trace
Fe_2O_3	2.26	S	0.39
CaO	0.33	Total C	.43
MgO	.14	Inorganic C	.13
TiO_2	1.14		
Oxide ratio	RO 0.158	Al_2O_3 1.00	SiO_2 2.476
Total linear shrinkage, cone 14	6.24		
Deformation temperature, cone 31			

General Conclusions

1. In Ohio the fields of flint clay of high heat duty quality are not inexhaustible, but are comparatively small and well defined.

2. The prospect of finding other deposits under deeper covering is not encouraging, in fact, drilling so far has not revealed any worthy of development.

3. The present fields have been worked for nearly fifty years which has exhausted much of the best material and, in general, that most easily available.

4. The known deposits are ample to support the present plants during their lifetime of fifty years but are not capable of supplying many new works which are required to take care of the increased consumption from year to year.

5. At the end of fifty years at the present rate of depletion most of the productive fields in this State will be exhausted or nearing this condition.

6. If conservation of our high heat duty clays is to be practised it should begin now, we should not wait until the supply is practically gone. The high heat duty clays should be conserved for high heat duty purposes only.

COLUMBUS, OHIO

GEOLOGY OF THE BARABOO GANISTER DEPOSITS[1]

By W. O. Hotchkiss

Introduction

The Baraboo district for many years has supplied large quantities of high grade ganister rock for the manufacture of silica brick. For a long period it has made Wisconsin the second state in rank in the production of this material. Pennsylvania has been first with two-thirds to three-fourths of the total used in the country, while Wisconsin has furnished approximately one-fifth. Quartzite is being produced for ganister purposes by the General Refractories Company, and the Wisconsin Granite Company, whose quarries are located at Ableman; the American Refractories Company, whose quarry is at Devils Lake; and the Harbison-Walker Refractories Company, whose quarry is south of North Freedom. Table I of production gives the tonnage and value of ganister produced by Pennsylvania, by Wisconsin, and the U. S. total for the years 1918–1921 inclusive, according to the reports of the U. S. Geological Survey.

Table I

		Pennsylvania	Wisconsin	U. S. total
1918	Short tons	858,374	276,424	1,297,874
	Value	$1,142,202	$303,760	$1,688,334
1919	Short tons	573,244	102,817	783,504
	Value	$ 718,317	$116,996	$ 974,326
1920	Short tons	761,750	182,680	1,095,390
	Value	$1,125,195	$216,609	$1,582,255
1921	Short tons	277,110	76,620	404,650
	Value	$ 359,936	$ 90,254	$ 522,185

The distribution of this quartzite in the Baraboo region is indicated on the accompanying map (Fig. 1). The quartzite forms high ridges surrounding a beautiful valley about twenty-four miles long and varying from two to six miles in width. The outcrops of this quartzite in this region are abundant and large so that the stripping problem in quarry operations is very minor.

Geology

The geology of the Baraboo quartzite has been best described by S. Weidman[2] and much of the descriptive matter has been taken from that report. Like practically all quartzite, this formation was deposited originally as sand on a shallow sea bottom. These original sand beds accumulated to a thickness of approximately a mile. Most of the beds were composed of very pure quartz sand with some few beds of less pure character which contained small amounts of clay. Toward the top of the

[1] Presented before Refractories Division, Pittsburgh Meeting, Feb., 1923.

[2] Wis. Geol. and Nat. Hist. Surv., *Bull.* **13** (1904).

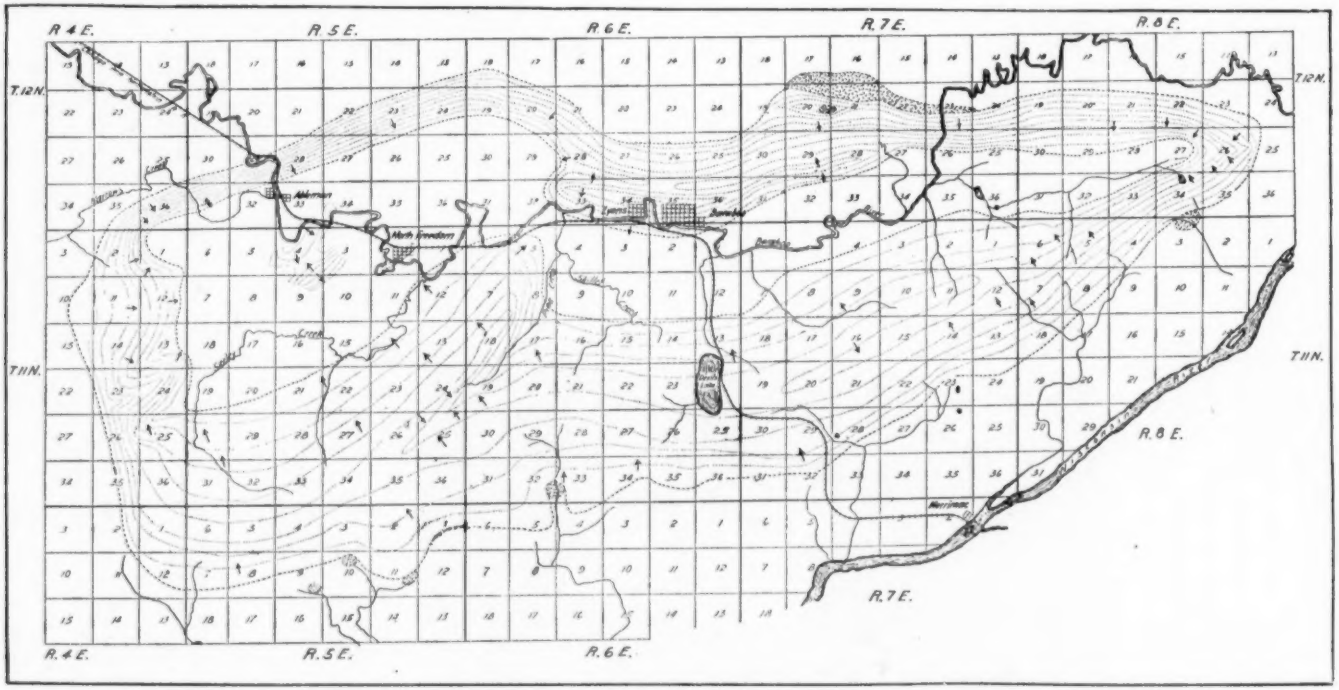


FIG. 1.—Map designed to show the structure of the Baraboo quartzite. The space between any two of the dotted lines represents an estimated thickness of 500 feet of quartzite. The direction of the dotted lines indicates the strike of the quartzite beds and that of the arrow heads the dip. The barred areas on the north and south sides of the quartzite represent outcrops of igneous rock, upon which the quartzite rests. From Weidman.

formation, and in a few places throughout its thickness, conglomerates are found which are composed to a very large extent of clear quartz pebbles. This original sand deposition was followed by a deposition of shale. This shale was a very fine-grained clayey material and accumulated to a thickness that is estimated at 500 to 1000 feet. At the present time none of this shale formation outcrops. It lies underneath the central portion of the valley together with the iron formation, the formation which was deposited upon the shale. This upper portion of the Huronian series is now obscured by the Cambrian sandstones which form the surface rock in the central portion of the valley. After the deposition of this material there followed the cementation of the sand grains by the filling of the interstices with pure quartz. Most of this quartz cement was deposited in crystal continuity with the sand grains so as to completely fill the pore spaces. The thin section under the microscope at the present time shows an irregular mosaic of quartz grains. Some of them, by reason of the fact that the original sand grains had a thin cover of iron oxide, still show the outline of the original grains, but most of the grains are so lacking in iron oxide covering that it is impossible to tell exactly what is the original sand grain and what is the added silica cement.

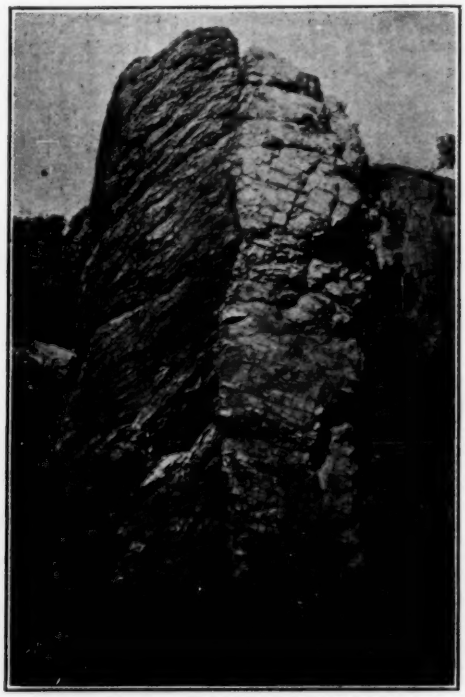


FIG. 2.—Van Hise rock. A mass of quartzite *in situ*, in the road through the Upper Narrows near Ableman. The bedding, which is nearly vertical, is indicated by the shading, while the secondary cleavage approaches horizontality.

After the cementing of the sands to quartzite the beds which now compose the Baraboo ranges were upheaved and folded into their present attitude. If you take a tablet $^1/_2$ inch thick and fold one edge of it up vertically you will note that the upper sheets glide over the lower ones and readjust themselves to the new position. In this great mass of quartzite a mile thick this readjustment between the beds had to take place.

The beds containing the greatest amount of clay were naturally the weakest and consequently were the ones which yielded during the folding. We

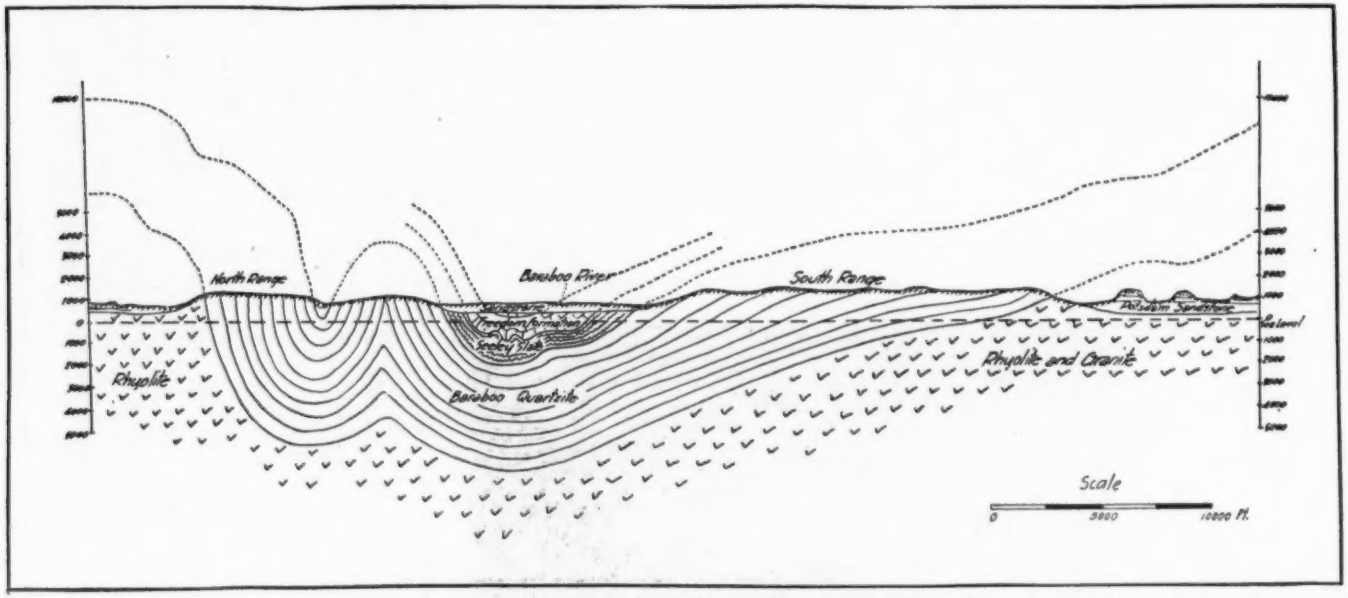


FIG. 3.—Generalized cross-section extending north and south across the Baraboo district. The horizontal and vertical scales are the same. The Baraboo quartzite rests unconformably upon the basement of igneous rock, consisting of rhyolite, granite, and diorite. The continuous lines represent the synclinal folds of the quartzite, slate, and freedom formation, upon which rests unconformably the overlying Potsdam sandstone. The dotted lines indicate the probable position of the quartzite, slate, and freedom formation above the present surface before they were eroded. From Weidman.

have in Fig. 2 (the Van Hise rock) the pure bed of quartzite to the right (originally the top bed of the two) and the somewhat more clayey quartzite to the left. In this latter bed is evident well-developed schistosity, even though the original clay content was probably less than 5%.

The folding to which this quartzite formation has been subjected is illustrated by the cross-section (Fig. 3), which was taken from Mr. Weidman's report. From this it will be noted that the beds on the South Range, which are those quarried at Devils Lake and to the south of North Freedom, have a rather gentle northward dip varying from 15° to 35° or 40°, while in the North Range the beds are approximately vertical. This vertical dip is also shown in Fig. 4.[1] This photograph was taken to show the east face in the gorge at Ableman. Similar cliffs occur on the west side of this gorge, and also at Narrows Creek, Narrows, about two miles west of Ableman, and in the Lower Narrows of the Baraboo River about 6 miles somewhat east of Baraboo.

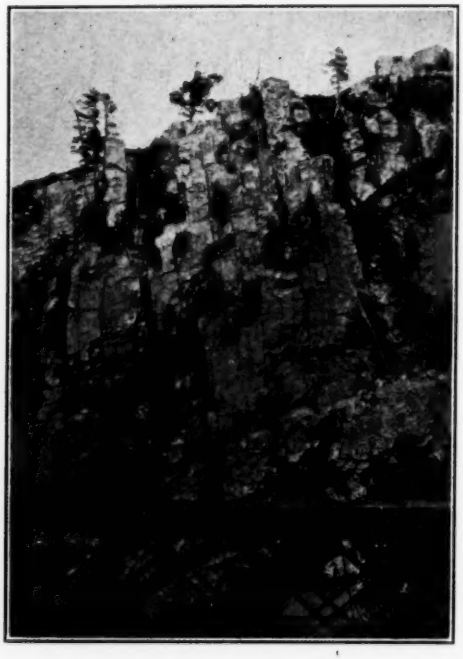


FIG. 4.—The east bluff of the Upper Narrows of the Baraboo at Ableman. Shows the south dip of the beds of quartzite. (After Salisbury and Atwood in Wis. Geol. and Nat. Hist. Survey, *Bull.* **5.**)

Physical Characteristics

The original sand grains, of which the quartzite is composed, are well rounded and subangular in outline and are of medium size. Probably the whole of these grains, if they could be separated, would go through a 30- or 40-mesh screen. The microscope shows in between these grains a complete filling of the interstices by crystalline quartz. There is a very small amount of iron oxide, chlorite and sericite in with the quartz grains. The color of the rock varies from a deep brick red to white, although there is very little of the white quartz present and it only occurs in very thin beds. In spite of the dark color, there is only a small quantity of coloring material. The predominant color is a rather grayish brown.

[1] Taken from Wis. Geol. and Nat. Hist. Surv., *Bull.* **5**.

Chemical Composition and Variation

The great mass of this quartzite is strikingly pure in silica. At the base there are conglomerates and shale beds which make the quartzite impure for a thickness of a very few feet, and the transition beds of Seeley slate which overlie it are a mixture of quartz and slate, but these are a relatively few feet in thickness. Another notable peculiarity of this formation is the complete absence of alkalies. This lack of alkali also persists into the Seeley slate overlying, of which Table II is a very careful analysis made by Dr. Victor Lenher of the University of Wisconsin and published in Weidman's *Bulletin:*

TABLE II

ANALYSIS OF SEELEY SLATE

	Per cent		Per cent
SiO_2	62.03	K_2O	trace
Al_2O_3	29.34	H_2O (at 110°)	0.01
Fe_2O_3	trace	H_2O (at red heat)	2.24
FeO	5.09	TiO_2	none
MnO	none	P_2O_5	0.08
MgO	0.29	Cr_2O_3	none
CaO	.16	CO_2	none
Na_2O	trace	C	none
		S	0.10
Total			99.40

From this it appears that this slate is almost wholly made up of silica, alumina and ferrous oxide.

The following analyses of the Baraboo quartzite were also made by the same analyst in 1911. In all of these analyses tests were made for alkalies and none found. In the note on these analyses the general stratigraphic position of the samples of which the analyses were made is given. These indicate that practically the whole of this formation is sufficiently pure in silica to be available for ganister. The samples that were collected for analysis were carefully taken to give very representative analyses of the localities selected. For this purpose a very considerable number of chips were taken from different parts of the outcrop or of the quarry and in Table III the number of chips is indicated.

Supply Extensive

From this information it is evident that there is a limitless supply of this material in the Baraboo ranges. As a matter of fact, the total amount of quartzite in this formation is measured by hundreds of cubic miles, and even though much of it would be unavailable because of depth, the quantities that can be quarried easily are so vast as to be limitless no matter what calls may be made upon them.

TABLE III

	Loss on ignition, per cent	SiO_2	Fe_2O_3		Al_2O_3	CaO		MgO
1	0.28	97.99	0.70	Fe = 0.49	0.99	0.01		0.03
2	.54	97.95	.70	Fe = .49	.79	.01		.01
3	.40	98.84	.33	Fe = .23	.41	.00	Less than 0.01	.02
4	.59	97.98	.90	Fe = .63	.50	.01		.02
5	.70	98.12	.36	Fe = .25	.79	.02		.01
6	.45	98.11	.41	Fe = .29	1.00	.02		.01
7	.56	96.62	.79	Fe = .55	2.00	.00	Less than 0.01	.03
8	.46	98.22	.23	Fe = .16	1.08	.00	Less than 0.01	.01
9	.62	98.93	.17	Fe = .12	1.27	.00	Less than 0.01	.01
10	.60	98.59	.23	Fe = .16	0.53	.03		.02
11	.44	98.81 (Includes CaO, MgO)	.08	Fe = .06	.67			
12	.33	99.04	.28	Fe = .20	.35			
13	.51	97.17	.97	Fe = .68	1.35			
14	.52	98.51	.16	Fe = .11	0.81			

1. American Refractories Co., Devils Lake. Taken from 4 cars, about 45 chips from each car. 180 chips. (1911)—Quarry 500–1000 feet from top of formation.

2. From ledge near center of quarry about 60–150 feet from railroad track at American Refractories Co., Devils Lake, Wis. 1911, 20 chips.

3. Specimens from Vilas Property, Devils Lake. 1911, 110 chips.

4. Samples from Claude Property, N. W. Corner Devils Lake. 1911, 73 chips. Within 500 feet of top of formation.

5. Mr. Kirk's Property, Devils Lake. 1911, about 50 chips. About the middle of the formation.

6. Specimens from Dyke Ringling's Property, Devils Lake. 1911, 45 chips. About the middle of the formation.

7. Sample from Hopkin's Quarry, Devils Lake, Wis. 1911, 65 chips. About the middle of the formation.

8. LeRue's Quarry at Ableman, Wis. Rock ready for shipment. Harbison-Walker Co. From 1 car and pile. 1911, 90 chips. About 1500–2000 feet from top of the formation.

9. Sample American Refractories Co. Hultz Site, 1 mile south of Ableman, Wis. 1911, 55 chips. Probably in upper part of formation.

10. Rattlesnake Den Site, Erswell Quarry Site, 1 mile south of LeRue, Wis. 1911, 65 chips. Near top of formation.

11. Sample from Rick Property, 1–$1^1/_2$ miles southeast of Ableman, Wis. 1911, 63 chips. Probably near top of formation.

12. Fleming Property, 1 mile south of Ableman, Wis. 1911, 43 chips. From upper part of formation.

13. Sample from Quarry of Wisconsin Granite Co., Ableman, Wis. Best hard rock. 1911, 58 chips. Near middle of formation.

14. Sample from the Narrows Creek, Narrows, 2 miles west of Ableman, Wis. 1911, 109 chips.

STATE GEOLOGIST
WISCONSIN

REFRACTORY CLAYS OF THE ALBERHILL, CALIFORNIA DEPOSITS

By B. M. Burchfiel

ABSTRACT

A brief description of the clay deposits at Alberhill, Calif., is presented. The more important refractory clays of these deposits are described. Chemical analyses are given, along with shrinkage, water of plasticity, and fusion point data.

Introduction

The Alberhill, California clay deposits are situated in western Riverside County about seventy miles southeast of Los Angeles in the center of a region that is noted for its large quantities of many different varieties of clays. This region, for the most part, lies in the Tamescal Valley, which was in Tertiary times an arm of the sea which extended northward into what is now San Bernardino County.[1]

The largest clay mine of this region is that of the Alberhill Coal and Clay Company at their famous "Mountain of Clay." This deposit was opened up several years ago as a coal mine. The coal, however, was of rather poor quality and limited as to quantity. Consequently it soon became of secondary importance, for enormous quantities of excellent clays were found both above and below the coal, and these proved to be of far greater value and importance than the coal. At the present time there is practically no coal mined here, but about 90% of the high grade clays used in southern California come from this deposit.

This single body of clay has been pronounced unique by many men who are familiar with clay deposits all over the world, because it contains such a large number of totally different clays in so small an area. Several years of development has opened up a pit in which there is exposed a face of clay approximately 2000 feet long, and varying from fifty to a hundred feet in thickness. There are a great number of slips and faults in this deposit, but the following cross-section is fairly representative:

No. of feet	Kind of strata	No. of feet	Kind of strata
3	Soil	4	Bone Clay No. W–105
20	Yellow Top Clay	4	Clay between Bone and Blue Clays
6	Yellow M. T. Clay	12	Select West Blue Clay
34	M. T. Clay	8	W. T. Blue Clay
6	Coal		Shale

Yellow Top Clay

This yellow top clay is not refractory, but it is used by some manufacturers to temper certain refractory mixes where hardness and density are desirable and very high refractory properties are unnecessary. It

[1] Fletcher Hamilton, "The Clay Industry in California," Calif. State Mining Bureau, *Prelim. Report*, No. 7, Jan., 1920.

is not a true clay, but is decomposed granite. It is quite yellow in color. At cone 12 it is nearly black, and shows some evidence of overburning. This material makes excellent red face brick when mixed with other clays.

PHYSICAL PROPERTIES

Linear drying shrinkage	7 %
Linear burning shrinkage	5.4% of dry length, at cone 12
Water of Plasticity	31.5%
Fusion Point	Cone 14

CHEMICAL ANALYSIS

	Per cent		Per cent
Ignition Loss	10.06	Lime	2.00
Silica	62.12	Magnesia	0.68
Alumina	19.22	Alkalies	1.22
Ferric Oxide	5.04		
Total			100.34

Yellow M. T. Clay

This clay is plastic and works well. It contains some free silica. It is quite yellow in color. It burns to a beautiful buff at cone 12, and is quite hard. No signs of overburning are apparent at this temperature.

PHYSICAL PROPERTIES

Linear drying shrinkage	9%
Linear burning shrinkage	4.4% of dry length, at cone 12
Water of Plasticity	32.4%
Fusion Point	Cone 28

CHEMICAL ANALYSIS

	Per cent		Per cent
Ignition Loss	10.08	Lime	0.52
Silica	58.06	Magnesia	.31
Alumina	27.48	Alkalies	1.12
Ferric Oxide	2.52		
Total			100.09

M. T. Clay

This stratum of clay is the main one of the deposit. It is a white, siliceous, plastic clay. It contains a fairly large quantity of free silica which occurs for the most part in well-defined streaks of very sandy clay. This sand can readily be sorted out if extra smooth clay is desired. But for all general purposes this is not done, for the percentage of sand throughout the entire stratum is not excessive. This clay burns to a light cream color at cone 12.

PHYSICAL PROPERTIES

Linear drying shrinkage	8 %
Linear burning shrinkage	2.2% of dry length, at cone 12
Water of Plasticity	24.3%
Fusion Point	Cone 29

CHEMICAL ANALYSIS (BURNED)

	Per cent		Per cent
Ignition Loss	0.16	Lime	0.42
Silica	73.66	Magnesia	Trace
Alumina	22.86	Alkalies	0.64
Ferric Oxide	2.36		
Total			100.10

Bone Clay No. W-105

This is a white clay, slightly spotted with small black particles of iron oxide, and in some cases pyrites. It is not at all plastic. When calcined, it is quite hard but it breaks up easily, and makes excellent grog for high grade fire brick. It burns almost pure white.

PHYSICAL PROPERTIES

Linear drying shrinkage	3 %
Linear burning shrinkage	9.2% of dry length, at cone 12
Water of Plasticity	23.4%
Fusion Point	Above cone 33

CHEMICAL ANALYSIS (BURNED)

	Per cent		Per cent
Ignition Loss	0.26	Lime	Trace
Silica	54.85	Magnesia	Trace
Alumina	43.43	Alkalies	0.86
Ferric Oxide	0.72		
Total			100.12

Clay between Bone Clay and Blue Clay

In the raw state the general appearance of this clay is very similar to that of the above mentioned bone clay No. W-105. This clay, however, contains some very finely divided silica which the bone clay does not have. This clay also contains a small amount of iron scattered all through it. When burned to about cone 12 this iron gives the clay a brown speckled appearance.

PHYSICAL PROPERTIES

Linear drying shrinkage	5 %
Linear burning shrinkage	7.3% of dry length, at cone 12
Water of Plasticity	24.2%
Fusion Point	About cone 33

CHEMICAL ANALYSIS

	Per cent		Per cent
Ignition Loss	10.72	Lime	Trace
Silica	61.20	Magnesia	0.05
Alumina	27.29	Alkalies	Trace
Ferric Oxide	0.77		
Total			100.03

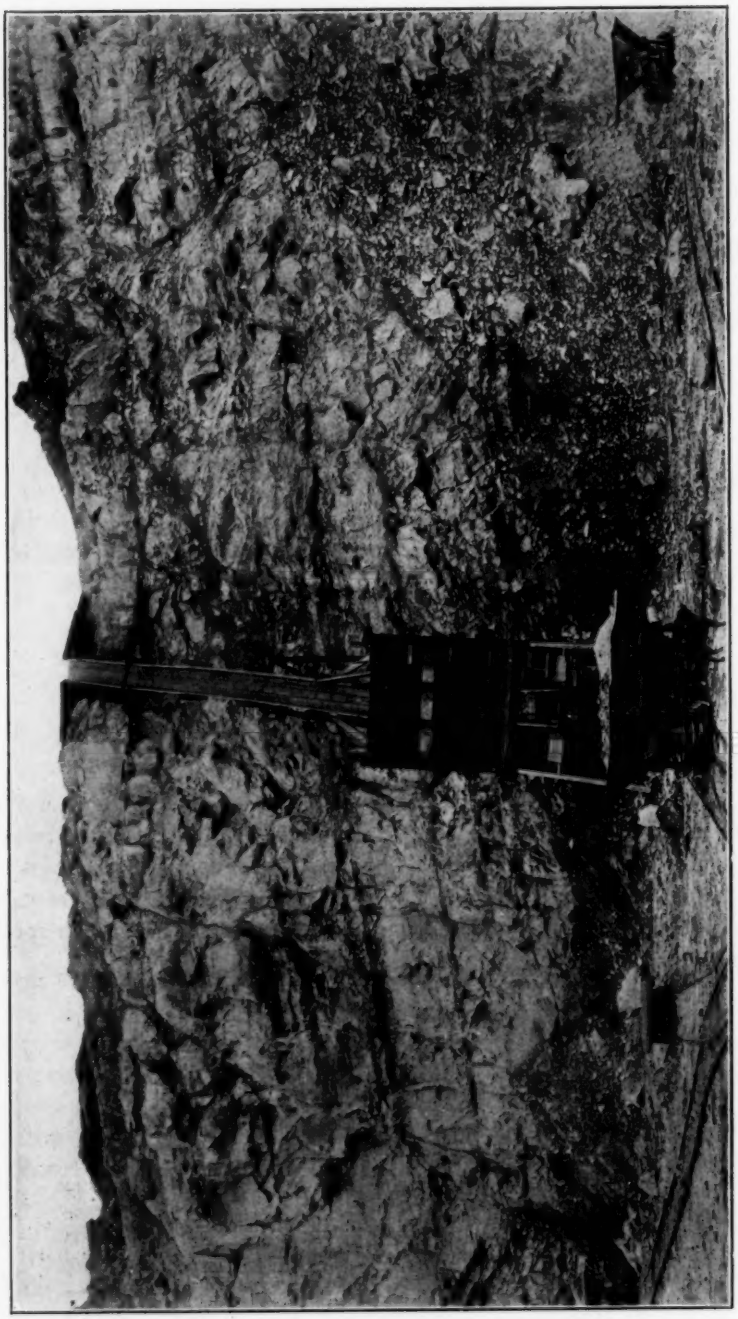


FIG. 1.—Rear wall, main pit showing fire clay over lignite.

Select West Blue Clay

This clay is very smooth and plastic. It is quite blue in color and slightly mottled with white. There is such a demand for this clay among the manufacturers of face brick, terra cotta, chemical stoneware, pottery, etc., that it is not used in fire brick to any great extent.

This clay dries extremely well. When burned it is very strong and hard. It is cream colored at cone 12.

PHYSICAL PROPERTIES

Linear drying shrinkage	5 %
Linear burning shrinkage	6.3% of dry length, at cone 12
Water of Plasticity	31.1%
Fusion Point	About Cone 32

W. T. Blue Clay

In regard to plasticity and general working qualities this clay is quite similar to Select West Blue Clay. Its color, however, has a decided green cast that is not apparent in that of the Select clay.

This clay burns hard and strong. At cone 5 it is light red in color. At cone 12 it is somewhat darker and contains fine black iron spots. This clay is excellent material for hollow building tile, roofing tile, etc.

PHYSICAL PROPERTIES

Linear drying shrinkage	6 %
Linear burning shrinkage	5.3% of dry length, at cone 12
Water of Plasticity	30.2%
Fusion Point	Cone 26–27

As this deposit continues to the north it rises gradually and its character changes. There is not so much clay on top of the coal. Underneath the coal the bone clays are replaced by about five feet of clay known as SH-4 clay. Underneath this the blue clays occur about the same as they do beneath the bone clays.

SH-4 Clay

This is a smooth ball clay of very high quality. It is used to a great extent in pottery of various kinds, and is suitable for use in china and porcelain mixes. A very high grade of refractories is made from this clay. It is dark gray-blue in color, and is extremely plastic and somewhat sticky.

When burned it is very hard and dense. It is white in color, and some samples have a light blue-gray cast.

PHYSICAL PROPERTIES

Linear drying shrinkage	5 %
Linear burning shrinkage	16.8% of dry length, at cone 12
Linear burning shrinkage	17.9% of dry length, at cone 14
Water of Plasticity	31.7%
Fusion Point	Above cone 33

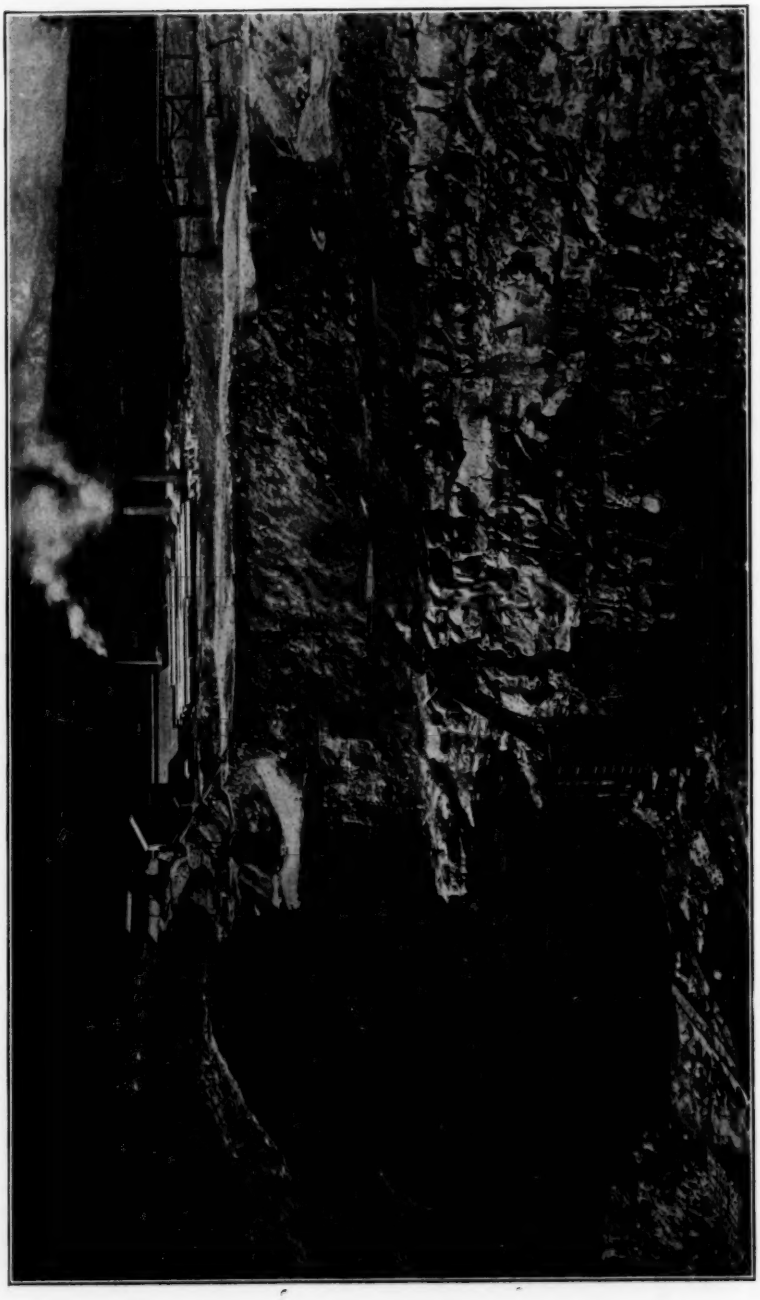


FIG. 2.

CHEMICAL ANALYSIS

	Per cent		Per cent
Ignition Loss	18.96	Lime	0.72
Silica	37.72	Magnesia	.05
Alumina	42.21	Alkalies	.09
Ferric Oxide	0.51		
Total			100.26

In addition to these clays just described there is a vein of bauxite about two feet thick which comes to the surface near the south side of the present open pit. Considerable silica, iron and fluxes are present in this bauxite at the outcropping, but it is probable that some of these impurities disappear deeper down in the deposit. It is nonplastic and quite refractory. It burns extremely hard. At cone 12 it is dark red in color, and has a total drying and burning shrinkage of 16%. Results of its chemical analysis are as follows:

CHEMICAL ANALYSIS

	Per cent		Per cent
Ignition Loss	15.32	Lime	0.62
Silica	38.96	Magnesia	.16
Alumina	35.76	Alkalies	1.02
Ferric Oxide	8.30		
Total			100.14

There are other good fire clays in this deposit, but these just described are the most important. Hill blue clay, which comes from another pit near the one just described, is a very plastic, highly refractory clay of excellent quality. But it, like some of the other clays, is used almost entirely in the face brick, terra cotta and other industries.

Sloan Clay

Another important clay deposit in this vicinity is that of the Los Angeles Pressed Brick Co. It is known as the Sloan Pit, and lies about a half mile southwest of the deposit just described. In this pit a face of clay is exposed which is over a hundred feet in length and approximately eighty feet in height. A representative cross-section is as follows:

No. of feet	Strata
40	Overburden and Yellow Top Clay
30	Sloan Clay
6	Sloan No. 5 Clay
4	Sloan Bone Clay. (Present level)
50	Red Clay

This yellow top clay is quite similar to that which is found at the Alberhill Coal and Clay Company deposit. There are a few veins of coarse sand in this top clay, however, which is used extensively in certain kinds of face brick.

This large body of clay is white and smooth and quite plastic. A few small veins of free silica are present, but these occur in well-defined layers. This clay is used extensively in face brick and terra cotta. It burns white.

PHYSICAL PROPERTIES

Linear drying shrinkage	8 %
Linear burning shrinkage	4.3% of dry length, at cone 12
Water of Plasticity	32.6%
Fusion Point	Cone 30

CHEMICAL ANALYSIS

	Per cent		Per cent
Ignition Loss	10.90	Lime	0.90
Silica	55.56	Magnesia	.20
Alumina	28.79	Alkalies	1.40
Ferric Oxide	1.77		
Total			99.52

Sloan No. 5 Clay

This is a very smooth, plastic ball clay, similar in all respects to the SH-4 clay just described. It is dark blue-gray in the bank, but is almost white when dry. It burns white and is extremely hard. This clay is used exclusively for highly aluminous fire-clay refractories.

PHYSICAL PROPERTIES

Linear drying shrinkage	5 %
Linear burning shrinkage	9.4% of dry length, at cone 5
Linear burning shrinkage	16.8% of dry length, at cone 12
Linear burning shrinkage	17.9% of dry length, at cone 14
Water of Plasticity	34.6%
Fusion Point	Above cone 33

CHEMICAL ANALYSIS

	Per cent		Per cent
Ignition Loss	15.72	Lime	Trace
Silica	41.48	Magnesia	Trace
Alumina	41.50	Alkalies	0.35
Ferric Oxide	0.80		
Total			99.85

Sloan Bone Clay

This clay is practically identically the same as the bone clay No. W-105 from the other deposit.

The red clay which underlies this clay is extremely plastic and easily worked. Very excellent hollow tile, roofing tile and red face brick are made from this clay.

Conclusion

It may be readily seen that this large variety of clays makes possible the manufacture of suitable refractories for nearly all purposes where clay refractories may be used. These clays are easily obtained in any reasonable amounts. Consequently the refractories industry in this region can be highly specialized. Each product can be made out of the clays best suited to withstand the conditions to which they may be subjected in actual use.

NOTE: The writer wishes to thank Jas. H. Hill, Pres., and Finlay Drummond, Vice Pres. and Gen. Mgr. of the Alberhill Coal and Clay Co., and J. E. Mills, Mine Supt. of the Los Angeles Pressed Brick Co. for valuable assistance in the preparation of this paper.

REFRACTORIES LABORATORY
LOS ANGELES PRESSED BRICK CO.
ALBERHILL, CALIF.

REFRACTORIES COLLOQUIUM—CONSUMERS' PROBLEMS

REFRACTORY REQUIREMENTS FOR OIL REFINING

By Alan G. Wikoff

ABSTRACT

Aside from boiler settings and such minor uses as fullers earth revivifying furnaces and sludge acid recovery plants, the main use for refractories in oil refineries is in fire still settings. With the shell type stills which were almost exclusively used in the past, service conditions are not severe enough to require anything more refractory than the best quality No. 1 fire brick, but some of the tube type cracking stills recently introduced are much more severe in their refractory requirements.

While all oil refineries may be said to have a common objective—that of treating crude petroleum by fractional distillation or pyrolysis so as to obtain products for which there is a greater demand—the methods employed vary considerably with the type of crude treated, the size of the refinery, and indeed change from time to time within the same plant to meet fluctuations in market conditions. In general, however, the crudes are treated in direct-fired stills of either cylindrical shell or tube type to yield the primary fractions, some of which may be marketed directly, others cracked in fire stills, others refractionated in steam stills, purified by chemical treatment in agitators, and so on through an almost endless variety of processes. From all of these the important points at which refractories are required may be summarized as follows:

1. Boiler plant
2. Fire stills:
   - A. Shell type:
     - (1) Crude or Topping
     - (2) Coking
     - (3) Cracking or Pressure
   - B. Tube type:
     - (1) Topping
     - (2) Cracking
3. Fullers earth revivifying furnaces
4. Sludge acid recovery

Because of the large amounts of process steam required, the boiler plants in many refineries are of considerable magnitude but as they do not differ materially from plants in other industries, consideration of their problems belongs properly with the subject of refractory requirements for boiler settings in general. It may be noted in passing, however, that in one of the largest complete refineries in the country the most severe service conditions for refractories are found in the boiler house.

Before turning to the question of fire stills, items 3 and 4 may be dismissed with brief consideration because the application of these processes is limited to a comparatively small number of refineries. In the treatment of certain products, particularly lubricating stocks, clarification by means of fullers earth may be required and for the regeneration of the spent earth various types of furnaces are used, such as rotary kilns, wedge

mechanical roasters and specially designed furnaces in which the earth drops vertically through baffled passages or slides over a series of slopes in direct contact with the flame.

One of the steps in the purification of such products as gasoline is agitation with a small percentage of 66 Baumé sulphuric acid, the acid combining with certain organic compounds to form a sludge which is drawn off at the bottom. A number of processes have been devised for the recovery of this sludge. In several of these the chief ceramic requirements are acid-proof stoneware rather than refractories, but one system concentrates the acid by blowing through it hot gases which are the combustion products of an oil burner supplied with air under pressure. As the gases reach the acid at a temperature of about 1200°F, combustion chamber refractories are subjected to quite severe conditions.

The remaining classification, fire still settings, constitutes the major application of refractories in oil refineries. From the standpoint of settings, it is most convenient to divide fire stills into two groups, shell and tube, depending upon the design of the steel container in which the oil is heated. In 1919, according to the Census of Manufactures, the refineries of the country had 4394 fire stills and 1480 pressure stills or a total of 5874 stills requiring refractories in their settings. Because of variation in size and in method of building settings it is not possible to estimate from this figure the total amount of refractories in use.

Shell Type Fire Stills

As the name would indicate, shell type stills are cylindrical in shape with bumped ends. They are supported in a horizontal position over an open setting, one end of which usually serves as a fire box, although a few stills are side fired. Capacities are rated according to the number of barrels of oil which constitute a charge and the shell dimensions corresponding to some of the more usual sizes are as follows:

Capacity—bbl.	150	300	600	1000
Dimensions—ft.	8 x 20	9 x 30	11 x 40	14 x 40

Although it cannot be taken as truly representative, for there is no design which is universally accepted in all details, the following description of a 1000-bbl., 14 x 40 feet crude still will give an idea of the way in which settings are built for shell stills. The shell, built up of heavy steel plate (the bottom sheets being $^1/_2$-inch best quality fire-box steel), is supported on each side by eight cast-iron or pressed-steel lugs, which rest upon 7-foot steel columns set on concrete foundations 6 feet 6 inches high, so that the lugs and center line of the shell are 13 feet 6 inches above the still foundation. Viewed from the end the inside width of the setting is 9 feet 6 inches at the bottom tapering outward as it rises until it is the full

width of shell at the lugs, where the setting ends. Above this point the shell is covered with blocks of heat-insulating material such as Sil-O-Cel, finished with a waterproof cement. Gutters on each side prevent rain from entering setting or combustion chamber. The heads of the still drums are insulated in a similar manner.

Front and rear walls are built up to conform to the curved underside of the shell, with 9 inches of fire brick toward the inside, then four inches of Sil-O-Cel, with the outside red brick or concrete. Two fire-brick lined openings in the front wall provide for firing and ash removal. From these a grate extends seven feet back to the front bridge wall, four feet high and faced with fire brick. About three feet from the rear wall is a second bridge wall which extends to within eighteen inches of the still bottom, so that its upper edge is curved. The space between the two bridge walls is filled with cinders so that the products of combustion are forced up against the bottom of the still and must pass through the 18-inch space between the still and the top of the rear bridge wall before passing to the 2-foot vertical flue immediately behind and then to the three-foot horizontal flue in the rear wall leading to the stack. The side walls are nine-inch fire brick backed with four-inch Sil-O-Cel. Where the cinder fill is used, the fire brick extends for a foot or so below the cinder surface, the lower portion protected by the cinders being of common brick. In brief, wherever exposed to combustion gases, the interior of the setting is faced with fire brick.

Settings of this type need nothing more refractory than No. 1 fire brick, the general requirements being medium grade with good wearing qualities rather than ability to resist high temperatures. The temperatures encountered depend upon the method of firing and upon the process being carried out in the still.

Fuel may be either oil or coal. Some refineries in the mid-continent field burn fuel oil which is unmarketable because of the high content of bottom settlings. The mineral matter in these bottom settlings may often cause slag trouble. Coal is usually fired by hand although stokers are used in some of the larger refineries. In the latter case, best quality No. 1 fire brick are required in the combustion zone.

Shell stills may be used for topping or skimming crudes, that is, removing simply gasoline and other light fractions, the entire residue being sold as fuel oil or cracked to obtain further quantities of gasoline; treating crudes to obtain a number of fractions; running certain types of crudes to dryness, until a thick layer of coke is formed on the still bottom; cracking heavy fractions by heating under pressure.

For topping and treating crudes, the stills may be operated intermittently and individually, or the continuous process may be used. In the latter, end-fired stills are cast in batteries of four to twelve, six being common,

and operated in groups of four, five, or more, each still in the group being maintained at a higher temperature than the one preceding it. Crude enters at the low temperature end and passes through each still in turn, heavier and heavier fractions being removed, until it finally leaves the last still as residuum. With this arrangement, a run may last for 10 to 15 days, or until the last still requires cleaning out, so that the setting suffers less from expansion and contraction than during batch operations for topping. The maximum oil temperature is in the neighborhood of 500° to 600°F.

In coking stills, the final temperature inside the still is about 890°F and a run averages forty hours. Cracking or pressure stills of the Burton type may hold 200 barrels or more and operate at 650° to 850°F under a pressure of four to five atmospheres, the furnace temperature being from 1350° to 1600°F. This is probably the most severe service in shell still work, best quality No. 1 fire brick being required.

As has been indicated, the temperature conditions for shell still setting are not extremely severe, and such refractory troubles as have been experienced are due as a rule either to spalling resulting from short runs which cause sudden temperature changes, or to improper laying of the brick. While in large refineries the settings may be constructed under engineering supervision, small refineries often depend upon local contractors who have had little or no experience in laying refractories. The result is that the manufacturers are frequently blamed for failures which are really due to improper use of the product.

Tube Stills

To meet the demand for fuel oil in California, there have developed a number of types of tube stills which permit continuous and economical removal of the lighter fractions from the crude, leaving the desired fuel oil. These types have been described and illustrated so completely in a 160-page report by J. M. Wadsworth[1] that it is unnecessary to go into detail here. In a Bell type plant, at Avon, California, crude is heated to 435–450°F by passing continuously through three rows of thirty-six 4-inch wrought iron pipes twenty feet long set across a furnace heated by oil burners in fire-brick lined Dutch ovens.

In the application of the tube still principle to the cracking of heavy fractions, extremely severe service conditions are encountered. In one cracking process of this type, combustion chamber temperatures as high as 2800°F are required in order to maintain the oil circulating in the tubes at 820°F. A coating of high temperature cement over No. 1 fire brick has

[1] J. M. Wadsworth, "Removal of the Lighter Hydrocarbons from Petroleum by Continuous Distillation," Bureau of Mines, *Bull.* **162.**

been found effective in eliminating refractory trouble. Since plants of this type can obtain about 30% of gasoline from ordinary fuel oil and still leave a residue marketable as fuel oil, they seem particularly capable of helping the refiners meet the ever-increasing demand for gasoline. While it is impossible to make any prediction in view of the involved patent situation, it is evident that extensive use of tube type cracking plants would greatly increase the demand for high grade refractories by the oil refining industry.

The writer regrets that it has not been possible to give more definite data in this brief review but the fact is that in the past no one in the industry has given much attention to refractories and data are accordingly unavailable. Should the demand for increased gasoline production be met by the use of tube type cracking plants it seems quite probable that the oil refiner will require more attention from the refractory manufacturers.

NEW YORK CITY

METALLURGICAL REQUIREMENTS FOR REFRACTORIES IN THE ELECTROTHERMIC METALLURGY OF ZINC[1]

BY B. M. O'HARRA

ABSTRACT

Refractory brick for lining electrothermic dry distillation furnaces must have a melting point of not less than 1600°C, must retain their strength at temperatures of 1400–1500°C, must be non-porous, and of uniform size. For lining electrothermic smelting furnaces, in which a liquid slag is produced, they must in addition to having these qualities be resistant to the corrosive action of highly heated slags which may be either strongly acid or strongly basic. The condensers are similar for both types of furnace. The brick for lining them need not have a high melting point but must be dense and of uniform size and must be very low in free iron oxide to withstand the disintegrating effect of carbon monoxide in the cooler portion of the condenser.

Refractory materials used in electrothermic processes for the treatment of zinc ores may be divided for the purpose of discussion into two classes: Those used in the smelting, or distillation furnace; and those used in the condenser. The preliminary roasting of the ores for treatment by an electrothermic method is the same as for the ordinary retort process, and is done in the same types of furnace so that no discussion of refractories for roasting furnaces is necessary here.

Electric Smelting

Electrothermic processes belong to two types: Electrothermic dry distillation, and electric smelting proper. Electrothermic dry distillation is similar in principle to the retort process, in which the ore is mixed with

[1] Presented before the Refractories Division, Pittsburgh Meeting, Feb., 1923.

an excess of coal and coke, the zinc distilled, and an unfused mixture of coke and gangue left as a residue. In the Fulton furnace, which is the principal example of this type, the ore is mixed with coke and formed into large briquets with pitch as binder. These briquets are baked to drive off the volatile matter from the pitch and are then set up so as to form a continuous resistor through which an electric current is passed, the charge thus being evenly heated by its resistance to the current. In other furnaces of the dry distillation type the heat is generated by its resistance to the passage of an electric current between two electrodes embedded in it.

In electric smelting proper only sufficient reduction fuel is mixed with the ore to reduce the metals contained, leaving no excess carbon, and fluxes are added to form a fusible slag with the residue, allowing the lead and precious metals to separate out as bullion and the copper as matt. In this type of furnace the heat is supplied by an electric arc or by the resistance of the part of the charge and slag which lies between two or more electrodes projecting through the roof of the furnace.

Requirements for Refractories

The requirements for refractories to be used in dry distillation furnaces are less exacting than for those to be used in smelting furnaces in which a liquid slag is produced.

In the former the furnace lining is not exposed to the action of corrosive slags; and in the Fulton briquet furnace the charge does not even come into contact with the furnace lining. Under these conditions the refractories need not be especially resistant to corrosion. They should have a melting point of not less than 1600°C, and since the furnace is of large size should be of sufficient strength to support considerable weight at temperatures of from 1400° to 1500°C. They should be non-porous, to prevent the absorption of large amounts of zinc, and of uniform size to allow laying with tight joints. They must withstand rather rapid changes of temperature between about 800°C and 1400°C without spalling or cracking. In short, the requirements are very similar to those for the lining of retort furnaces.

Refractories used in the lining of electric smelting furnaces in which the residue is melted to a liquid slag must fulfill all the above requirements and in addition must resist the attack of corrosive slags at a high temperature. These slags are usually either very basic or very acidic and corresponding basic or acid refractories must be used. Since in these furnaces the heat is supplied by a buried arc or by the resistance of the part of the charge lying between carbon electrodes near the middle of the furnace, the lining is liable to be subjected to local heating considerably higher than the average temperature of the furnace, and suitable provision must be made for this in the quality of refractories used.

Since electric heat is expensive, the lining of either dry distillation furnaces or smelting furnaces is always backed up by some kind of heat insulation. For this some such material as Sil-O-Cel, having a low heat conductivity, is used. The insulating material is not subjected to a high temperature and hardly comes under the heading of refractories.

The Bricks Used in Condensers

The type of furnace used for the volatilization of the zinc does not affect the kind of condenser to be used. The temperature in the condenser varies from something below 1000°C to about 500°C. The brick used in the lining need not be very refractory, but should be dense and of sufficient uniformity in size to be laid with tight joints. In the part of the condenser in which the temperature is about 500°C or slightly higher a peculiar condition must be guarded against. The gas in the condenser is a mixture of zinc vapor and carbon monoxide. At temperatures of about 500°C carbon monoxide tends to break down into carbon dioxide and elemental carbon, according to the reaction:

$$2CO = CO_2 + C$$

This reaction is greatly accelerated by the presence of iron, which acts as a catalyzer. If the refractory lining of the condenser contains specks of iron oxide these will be reduced by carbon monoxide to metallic iron. Carbon is then deposited around this as a nucleus, and exerts sufficient expansive force to disrupt the lining in a short time.

This effect has been investigated at the Mississippi Valley Station of the Bureau of Mines and a report of the investigation was published in the August number of this *Journal*.[1]

In the present retort practice condensers are subjected to much handling and last only for about ten days, but in electrothermic processes where large permanent condensers are used, the lining must last much longer than this, and the effect of carbon monoxide becomes important. It can be prevented by the use of iron-free refractories. In fact, the use of iron-free material for the lining of condensers is practically essential in the electrothermic metallurgy of zinc.

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[1] B. M. O'Harra and W. J. Darby, "The Disintegration of Refractory Brick by Carbon Monoxide," *Jour. Amer. Ceram. Soc.*, **6** [8], 904–14 (1923).

OUTLINE OF REFRACTORY REQUIREMENTS FOR THE IRON AND STEEL INDUSTRY[1]

By F. W. Davis

ABSTRACT

One of the greatest obstacles to the development of better refractories for the iron and steel industry has been the failure of the iron and steel men to give refractory manufacturers accurate detailed analysis of chemical, physical and thermal conditions to which the refractories are to be subjected. This paper summarizes briefly some of the conditions to be encountered in the major processes.

Blast furnace refractories may be divided according to requirements as follows: *Hearth* and *Bosh* brick should withstand the scouring action of molten iron and acid slag at temperatures around 1800°C. *Inwall* brick should be impervious to hot, reducing gases, should resist the sand blast action of the fine particles of ore carried by the gas, should have a low coefficient of thermal expansion and should possess sufficient compressive strength to support the weight of the upper part of the furnace. *Top* brick should be as dense and resistant to abrasion as possible. *Downcomer, Dustcatcher* and *Gas Line* brick should be dense and resist sand blast action of gas heavily laden by particles of charge. *Hot Blast Main* and *Bustle Pipe* brick should be of low heat conductivity. *Hot Blast Stove* brick should not vitrify at 900°C, should have maximum capacity for absorbing and giving off heat, and be of high compressive strength.

The by-product coke oven is becoming a big factor in the refractory fields and has major requirements as follows: *Canals* and *Ovens* require brick of high thermal conductivity which will resist sudden changes in temperature and will not be affected by reducing gases at high temperatures. *Checker* brick should have great capacity for absorbing heat.

Bessemer converters require brick resistant to slag at temperatures from 1600° to 1700°C, the nature of the slag being determined by whether the process is acid or basic.

Requirements for open hearth furnaces are as follows: *Roof* brick (both acid and basic furnaces) must not only be capable of maintaining an arch but should withstand as much as possible the action of iron oxides at temperatures of 1800°C. *Checker* brick (both acid and basic furnaces) should possess a maximum capacity for absorbing and giving off heat, and a minimum chemical affinity for oxides from charge. *Ports* (both acid and basic) must withstand the action of slag splashes, also direct action of flame. The *hearth* of the furnace consists of several courses of brick (acid or basic depending on the process) upon which is built the hearth proper by means of many layers of crushed refractory of the same nature. This crushed material must frit together at high temperatures without excessive softening.

Introduction

The part played by refractory materials in the metallurgy of iron and steel is of greatest importance, but strange to say, there is at present very little standardized information as to complete requirements for the various processes. In other words, to the present time, neither the producer nor the consumer of refractories possesses sufficient information to have a common talking point, and it could be said that we need to develop what might be termed a new set of units for refractory materials which would tell more as to their behavior in actual practice.

[1] Presented before the Refractories Division, Pittsburgh Meeting, Feb., 1923.

Many firms purchase refractories on chemical composition alone, and a few others combine chemical analysis with physical tests, but as far as I can learn, there is no standard procedure to determine the relative merits of different refractory products for the various uses for which they are manufactured.

The knowledge of the material used in the refractory is essential for proper selection. This, however, taken alone, may be very misleading for the factors of physical structure of the material, size of grinding during preparation, methods used in mixing and the heat treatment in firing are of almost equal importance.

The greater fault responsible for this very unsatisfactory condition lies with the consumers in their failure to give the refractory manufacturer an accurate and detailed analysis of the actual conditions, chemical, physical and thermal to which the desired refractory is to be subjected. With this in view it is the object of this paper to state in some detail the conditions to be encountered in the various processes, rather than to attempt to designate a particular refractory which should be used.

Blast Furnace

Probably one of the earliest consumers of refractory materials in the ferrous industry was the blast furnace operator. Under normal operating conditions, the grade of refractory used in the construction of the blast furnace will determine more than any other item the life of the furnace. With reference to refractory requirements the blast furnace itself is divided into three major zones, the hearth and bosh zone, the inwall zone and the top zone, each differing from the other as to requirements.

Hearth and Bosh.—The "hearth" and "bosh" bricks must be of a material which will resist the scouring action of molten iron and a more or less acid slag. They should be sufficiently dense to prevent penetration to any great extent of the molten material. There should be no appreciable shrinkage at the temperatures (1800°C) to which they are exposed. They should be of uniform and regular dimensions to permit being laid with minimum-sized joints. There will be very little abrasion in this section and the greatest load they will normally be called upon to carry will be little more than the weight of the molten iron and cinder plus the blast pressure.

Inwall.—Brick for the *inwall* or middle section of the furnace will not be subjected to such severe chemical or thermal conditions. They will, however, be subject to considerable abrasion due to the movement of the burden as well as the "sand blast" action of the ascending gas heavily laden with small particles of the burden. These brick must have sufficient compressive strength to support the weight of the upper part of the furnace. A low coefficient of thermal expansion is desired to avoid

any distortion of shape on heating. Another factor to be considered in connection with the brick to be used in this section is the permeability to gases at high temperatures. This is a most important factor due to the destructive action of carbon monoxide in contact with the iron oxide present in the brick. In this connection, too, there are certain metallic vapors present when smelting ores of some localities which penetrate the brick with very destructive and sometimes disastrous results; zinc is the greatest offender in this respect.

Top.—In the *top* section of the furnace the conditions of abrasion are extreme and the temperatures are at a minimum, hence the brick should be as dense and resistant to abrasion as possible, at the expense, if necessary, of the refractory qualities. It is just as essential that the top brick resist abrasion as it is to have a highly refractory brick in the high temperature zone, for as soon as the top brick wear away to any great extent, there will be unequal distribution of the burden which in time will necessitate blowing out for repairs.

Pipe Linings.—The brick in the *downcomer, dustcatcher* and *gas lines* will be subjected to the "sand blast" action of the gas and should resist abrasion. For the *hot blast mains* and *bustle pipes* the idea is to conserve as much heat as possible so that a brick of minimum heat conductivity is desirable.

Stoves.—The *hot blast* stoves constitute the largest auxiliary to the blast furnace and require more brick of a special nature than any other unit including the furnace itself. The function of the hot blast stove is to absorb as much heat as possible from the combustion of a portion of the top gas and deliver this heat with maximum efficiency to the air being blown into the furnace. For this reason it is of greatest importance that the brick used will absorb a maximum amount of heat and give it off readily to cold air being blown through. The temperatures will run as high as 900°C and the brick must not vitrify at this temperature. In addition to this the brick must have high compressive strength.

By-Product Coke Oven

One of the more recent users of refractory material and at the same time one which is well in the lead as regards tonnage required is the by-product coke industry. In the by-product coke oven we have two major classifications, namely, the brick used for the canals and ovens, and the checker brick.

Canals and Ovens.—For use in *canals* and *ovens* the brick must have a high thermal conductivity to promote rapid coking. They must resist sudden changes in temperature which will be encountered in the charging and pushing operations. The coefficient of thermal expansion should be low. The chemical analysis of this brick should show no element which

will be acted upon by the highly reducing gas to the detriment of the physical properties of the brick.

Checker.—The major requirement of *checker work* brick is to be able to absorb the maximum amount of sensible heat from the waste gases passing through the checkers and to give it up to the cold air in the other portion of the cycle of operation.

Bessemer Process

The refractories used in the acid Bessemer process are subject to the action of a highly siliceous slag at a temperature of from 1600° to 1700°C. The greatest trouble encountered with refractories in this service is found directly around the tuyères, where the iron oxide slags the acid lining away. For this reason the bottoms of the converters are made separate so as to be readily replaceable.

The basic Bessemer process is little used in this country because of our lack of high phosphorus pig. In this process the slag is highly basic so that the lining will of necessity resist a hot basic slag. There will also be some accumulation of the oxides of phosphorus silicon and sulphur which may be detrimental to the lining.

Open Hearth Process

The open hearth process is divided into two major divisions, acid, and basic. For general consideration of the furnace, aside from the hearth section, no marked difference is shown between the two processes. The checkers, gas mains and roofs used are the same in both.

Checker.—Inasmuch as over 75% of the total heat charged to the open hearth furnace leaves as sensible heat in the gas, one may readily see the importance of having efficient regenerators. The brick used will be subjected to temperatures as high as 900°C and from time to time splashes of slag, either acid or basic as the case may be, will find their way to the checkers. In addition to this, the flue gas is always charged with fine oxide particles from the bath which have a tendency to impinge and fuse on the checker brick. From this it is evident that the desirable qualities for checker brick are a maximum capacity for absorbing heat with a minimum affinity or slagging action with oxides from the charge and the slag itself.

Roof.—The roof of the open hearth furnace has proven in most cases the limiting factor in the life of the furnace, and is the point at which the greatest economy might be accomplished by improved refractory materials. In present practice, open hearth roofs are built of the purest silica brick obtainable. In spite of the fact that every effort is made to prevent the direct impingement of the flame on the roof, this section is one of the hottest parts. Together with the intense heat of about 1800°C,

the roof is subject to an atmosphere containing considerable concentration of oxides of iron. The effect of the iron oxides is readily seen on the examination of roof brick taken from service in that the lower half will be completely impregnated with iron and the structure of the brick destroyed. Under these extremely severe conditions, brick used in a roof must possess sufficient strength to maintain an arch and support their own weight.

Ports.—The "ports" of the furnace must also be constructed of the highest grade refractory material as these parts are subject to the direct play of the flame as well as the iron oxides and some slag splashes.

Hearth.—The hearth of the open hearth furnace is usually built up primarily of brick either acid or basic according to the process, and then filled in with similar crushed material. This filling material must be extremely refractory and have a long range of vitrification, *i. e.*, must frit together at high temperatures without fusion or excessive softening.

For the basic process in connection with the above, the refractories used in the hearth must be burned until they shrink, and become very dense and must be of such a nature as not to slake readily. They will be subjected to the action of carbides, phosphides and silicides to a limited degree.

In the basic process it is necessary to provide a high grade neutral refractory which is placed in the furnace wall between the basic hearth section and the acid wall to prevent these two from action with each other. In many plants the ports are covered with neutral brick as well to prevent the basic slag from splashing on and damaging the acid brick used for this portion.

Crucible Steel Process

Crucibles for making steel were formerly made of fire clay. The American practice, however, is to use 50% fire clay and 50% graphite which increases the life of the crucible about 100%. Crucibles in steel making are subject to very severe mechanical strains at high temperatures as well as slagging action at the top of the molten steel.

Furnaces for Reheating, Annealing, Tempering, etc.

Under this group will fall all of the furnaces for the further refining and finishing of steel, the requirements for which as to refractory materials can, in a general way, be said to follow the trend of the open hearth in a somewhat less exacting degree. The temperatures used in these furnaces should never approximate the open hearth furnace temperatures and the only slag found here will be formed from the oxides of iron formed during the process of heating. When checkers are used, the same specifications will apply as with the open hearth. The roofs though subject to some-

what lower temperatures must have practically the same characteristics. The hearths or "bottoms" as designated in these furnaces are required only to retain the iron oxide cinder formed in the heating.

MILFORD, DELAWARE

METALLURGICAL REQUIREMENTS OF REFRACTORIES IN COPPER SMELTING AND REFINING[1]

BY FRANCIS R. PYNE

ABSTRACT

The requirements of refractories in the copper industry may be classed as follows:

1. Resistance to temperatures
2. Resistance to chemical action
3. Ability to withstand sudden temperature changes
4. Minimum absorption of slag and metal
5. Absence of manufacturing defects.

Resistance to Temperature

The ability to withstand high temperatures is in general of importance only in the reverberatory smelting of fine ores. Here we have a furnace approximately 100 feet in length into which the roasted ore is charged at one end while the molten slag and matt collect at the other end. And as the object of this operation is to smelt the greatest possible tonnage in a given space of time, it follows that the higher the temperatures obtained, the better. It is therefore apparent that in this case the refractory that will withstand the higher temperature, other conditions being equal, is more desirable.

In other metallurgical operations, such as roasting, converting and refining, the temperatures are not excessive and in these operations the question of refractoriness is of secondary consideration.

Resistance to Chemical Action

Resistance to chemical action is of the greatest importance. The copper metallurgist deals with highly corrosive slags, matts, oxides, and metals and unless the proper refractory is selected for each material, there will be constant interruptions to the process due to shut downs for repairs. As the products formed in the smelting of copper ores are strongly basic, the natural tendency is towards the basic refractories such as magnesite and chrome. For roof work, however, silica is almost universally used except in the case of very low temperature work or where the silica would be subjected to such corrosive action of slags, flue dusts, etc., as to make its use uneconomical.

[1] Presented before the Refractories Division, Pittsburgh Meeting, Feb., 1923.

Clay brick is commonly used for flues, for side walls and roofs in low temperature work and almost universally for fireboxes in coal fired furnaces. Due to the high price of the magnesite and chrome refractories, there is a constant endeavor to keep their use down to a minimum and to substitute clay brick whenever possible. This is particularly desirable in refining operations where the slags formed are not as highly corrosive as in the smelting operations, but nevertheless are very basic.

However, clay refractories vary from highly siliceous to neutral and there must be considerable care exercised in their selection not only for furnace linings but for fireboxes. A highly siliceous clay refractory will not withstand basic slags, neither will it withstand a corrosive ash from the coal, and it is generally necessary to use the more neutral clays for this work, although there are, of course, exceptions due to local conditions.

Many producers of clay refractories do not appear to realize the importance of the chemical composition of their products. As long as their product will stand a proper fusion test they appear to be satisfied and seem to feel that the consumer who desires to know something about the chemical composition, is technical and not practical. The writer has known instances where the manufacturers of clay refractories have had no analyses made of their product for years. However, there are indications that such conditions are changing for the better.

Sudden Temperature Changes

The ability to withstand sudden temperature changes is desirable as in many operations there is a sudden increase or decrease in the temperatures of operation. Unless the refractory possesses this ability, it will spall badly and have a short life.

Minimum Absorption of Slag and Metal

One of the very important requirements for copper refractories is the ability to withstand penetration of slags, matts, and metal. As the products are of considerable value it follows that if the refractories are porous they will tie up a lot of copper, silver, and gold which means not only a heavy interest charge but also a heavy expense in the retreatment to recover these metals, which adds greatly to the cost of operation. It also follows that any refractory, irrespective of its chemical composition, that is so porous as to permit of considerable absorption by capillary attraction, will have its properties so changed as to be destroyed in a relatively short time.

Obviously, the cure for porosity in refractories that come in contact with molten materials lies in the use of as dense a brick as is possible, and this generally requires fine grinding and machine pressing. Or else the result may be accomplished by the use of a refractory that will become

slightly glazed at the operating temperature and close up the pores. However, to the writer's knowledge, this type of refractory has not as yet been satisfactorily developed.

Absence of Manufacturing Defects

The absence of manufacturing defects is very desirable but unfortunately, like death and taxes, they are still with us and are a source of considerable annoyance. The chief defect lies in non-uniformity of product in that straights and shapes are frequently made of different material, have different fineness of grind, and different degrees of firing. The same shape may also vary widely. On this account it is not surprising that the mechanical properties are not similar and when refractories having such different characteristics are placed side by side in a structure and subjected to the same operating conditions, that failures frequently occur.

Irregularity in the thickness of the individual pieces makes it necessary to have thicker joints than are desirable and will frequently cause local failure. Warped surfaces, though slight, are fertile sources of weakness. Fire cracks, defects in molding, setting, or firing may become very serious as they not only adversely affect the quality but this effect is greatly magnified at increased temperatures.

As practically all refractories are subject to further change in volume upon heating for long periods, particularly the clay refractories, it becomes of importance that they should be fired at a temperature not less than the maximum temperatures at which they are to be used. Unless this is done there may be such an excessive volume change during the operations as to break down the structure in which the refractory is used. It is, generally speaking, probably true that the harder a refractory is fired in the kiln, the more satisfactory it will be.

Elizabeth, N. J.

REFRACTORIES FOR STOKERS

By George I. Bouton

ABSTRACT

An outline is given of the general uses of refractories for stokers, and the requirements for an ideal fire brick. Temperatures which a refractory must stand are given and some of the troubles due to fluxing and spalling are described. Some analyses are made of typical brick and troublesome ash.

Introduction

Uses of Refractories.—It would be difficult to imagine a stoker without refractories forming some part of its setting, or the connection between the stoker and the place of use for the heat which has been liberated. Even the small underfeed stoker placed in the furnace of a Scotch marine

boiler has need of some refractories. The overfeed stokers, the inclined side feed, the inclined front feed, the traveling grate, all need arches and various inclosing walls. The underfeed stokers from the little single retort to large multiple retort, require inclosing walls, and in some cases, covering arches; some of these are getting more and more difficult to maintain. If the refractories fail to stand the strain the stoker manufacturer is the loser. Naturally he is more or less interested in refractories.

Requirements of a Refractory

If the stoker man could get it, he would like a refractory that would act as a reflector to aid the heat on its way to the place of use; one which will not change size or shape with changing temperatures; one which will not absorb or transmit heat; one which will not combine chemically with the products of combustion, or the waste material carried by the products of combustion; one which will stand considerable load at high temperature; one whose pores are fitted with double acting check valves to prevent leakage in either direction; one which will not get tired and drop on to the fuel bed, or other inconvenient place at inopportune times. Such a refractory is the kind we should like to find.

The user of a refractory is not interested in why it fails except to prevent a repetition of failure.

Tendency toward High Temperatures.—There is a continual tendency toward higher temperatures through reduction in excess air. With air at 70°F a high grade coal burned with 20% excess air and without radiation or other losses would produce about 3770°F. If the air were preheated to 270°F, the resulting temperature would be about 3930°F.

Fluxes Injurious to Refractories.—All coal carries ash, and this ash is made up in part of material which, at furnace temperatures, forms an active flux for refractories. Where the percentage of fluxes in the ash is small, the ash is not troublesome.

A refractory which would stand up three or four years in average service with the general run of coal might fail in forty to sixty days in the same service with coal having an ash high in fluxes. The writer's attempts to find a brick which would withstand the fluxing of the ash have not been particularly successful. It has usually been necessary to advise a change in coal. Under the market conditions of the last six or seven years, changing coal has not been easy.

Several years ago I asked a refractory expert whether there was a brick made which would stand up under the bombardment of fluxes. He told me that I ought to be satisfied with a brick that served satisfactorily in 90 or 95% of the installations. He failed to appreciate that failure in 5 or 10% of the cases might be very serious and expensive.

A refractory which was right chemically and which would also stand other strain would be universally useful for stoker furnaces.

As the writer's early troubles with fluxing were with brick running about 66% silica, the natural thing was to try a brick higher in alumina. So far the attempts have not been successful, as shifting the trouble from fluxing to spalling has not helped matters.

Difficulties from Spalling.—Failure in a few months due to spalling is more serious and annoying than failure in a similar length of time due to fluxing, for the field of failure is much more extensive, since it is not limited to plants burning particular coals. "Spalling," when it happens to be in large pieces, two or four inches thick, is called "slabbing."

So far as the writer's experience goes, brick running more than 40 or 42% alumina have spalled seriously. Whether spalling is due to insufficient bonding power of the clay or to structure or to some fault in the process of manufacture, I shall not attempt to say. We need brick running fairly high in alumina now, and will need them more in the future.

Some of the brick which I have analyzed are as follows:

TABLE I

	1	2	3	4	5	6
Silica	66.66	59.00	53.00	51.58	48.05	43.80
Alumina	31.32	38.06	43.99	46.07	46.62	51.55
Iron Oxide	0.58	0.71	1.43	1.63	2.42	2.73
Lime	.50	.80	0.60	0.34	1.30	0.55
Magnesia	.45	.68	.30	trace	0.20	.45
Titanium Oxide	?	.43	?	1.06	.10	.32
Alkalies	0.28	...	0.54	0.10	trace	...
Melting Point Degrees F	3110	3047	3092	3074	3083	3164

Numbers 1 and 2 have not seriously spalled. Numbers 3 and 4 spalled considerably, while 5 and 6 spalled very badly.

Analyses of the coal, the ash and the slag formed on the brick in a case where the brick were badly slagged, were as follows:

TABLE II

Slag from Comb. Chamber, Southern Ill. coal					Ash from
1. Glassy	2. Reddish	3. Dark gray		Slag	W. Va. coal
49.45	53.50	57.69	Silica	48.95	41.91
25.36	31.46	28.43	Alumina	25.10	18.41
5.74	4.76	3.99	Iron Oxide	16.17	24.80
6.05	7.56	7.38	Calcium Oxide	4.17	11.28
1.55	1.03	1.03	Magnesium Oxide	1.05	1.95
None	1.69	1.49	Alkalies	3.26	1.23
			Melting Point Degrees F	1980	

The brick was No. 1 of Table I.

Relative Price of Refractories.—The price of a refractory at the kiln is a portion, usually a small portion, of the cost of that refractory in place ready for service. Adding 50% to the price of the refractory at kiln will add 20 or 25% to the cost in place. If adding 50% to the price at the kiln will obtain a brick which will give 100% increase in life, it would appear to be good business to buy the higher-priced brick. Unfortunately, much of the buying is done by people who can see only the price. Some of the trouble is also partly due to the fact that the person selling the brick starts out with the idea that the only way to sell is to name a low price, and the business is taken at a price which means a present to the purchaser or an inferior brick.

I mentioned above the tendency toward increase in furnace temperatures. Where the walls are outside walls, and as in the old days, only eighteen inches thick, the refractory is helped out by radiation from the outer surface. This assistance is being eliminated by increasing thickness of the walls, and by the addition of insulating brick. An ordinary red brick will stand a considerable furnace temperature if it is thin enough and if it is sufficiently cooled by air circulation. There is a possibility of helping matters by taking the air supply through ducts built in the walls, inside the insulating brick, but this will materially complicate the setting and air supply particularly in the case of large forced draft stokers.

In spite of all ameliorating conditions, it will be necessary to deal with continually increasing temperatures. What is needed is a brick which will stand a very high temperature; one which will not spall; one which will stand pressure at the temperature of use and one which will resist the fluxing action of ash.

DETROIT, MICH.

THE VALUE OF UNIFORM FIRE BRICK FROM THE STANDPOINT OF THE CONSUMER[1]

BY R. F. HARRINGTON

Introduction

Our experience with refractories for large tonnage air furnaces melting high grade cast iron, has been principally from Grahn, Kentucky, Cumberland, Maryland and Clearfield, Pennsylvania.

The use of large amounts of brick from all of these sources in our practice has led to the definite conclusions, namely that:

(1) From any of these districts it is possible to obtain brick generally satisfactory for our furnace practice.

[1] This paper was presented before the Refractories Division, Pittsburgh Meeting, Feb., 1923.

(2) The clays from certain districts are better suited for certain purposes than clays from other districts; and furthermore, only with careful testing of the brick under careful and scientific supervision can the brick best suited to a given purpose be determined.

(3) Brick from manufacturers in all districts frequently exhibit marked differences from shipment to shipment in service rendered.

Most important of all from the consumer's standpoint, is the lack of uniformity from shipment to shipment. A large amount of delay and monetary loss to the consumer is incurred by failure to receive brick of uniform quality, especially in reference to the important properties of refractoriness and the resistance to spalling. Frequently initial tests on carload lots indicate unusual possibilities, but subsequent shipments fall far below the results obtained on initial test. The writer does not believe for one moment that this condition exists because of any desire on the part of the manufacturer to misrepresent his brick by unusually good quality on initial tests. Rather does it indicate the difficulty of the problem when it is realized that the manufacturer would certainly do everything in his power to have at least his initial brick representative of brick that he could furnish under normal conditions.

In many instances we have used thousands of brick with entire satisfaction from different producers only to have two or three carloads of brick received which were entirely unsatisfactory for our work.

Conditions demanding immediate use of these brick often meant that an entire furnace was built of inferior brick. Again, a few of these brick may be placed in a roof in conjunction with good brick and after a few heats cause the failure of the entire roof, with consequent loss of the good brick as well as the inferior brick. It is such results as these, with the consequent delays, that are of much concern to the consumer.

I desire to point out that these conditions are not conditions obtained only under poor furnace control, or the use of inferior grades of coal, but occur with furnace conditions under absolute control, unchanged design and unchanged supply of coal.

Often as further evidence to convince the brick manufacturer, whose representative may be on the job, that conditions are as have been stated, a few courses of the brick under question alternated with other brick show very clearly the melting or spalling of the inferior brick.

At what conclusion can the consumer arrive other than the fact that the producer in many instances has failed to give proper supervision in the manufacture to insure proper handling of material, or that the clays involved have changed in character with consequent bad effect on the final product.

Where it has been suspected that the clays have been at fault the scientific investigations by the Mellon Institute, or similar institutions or organi-

zations, have indicated the cause and ultimately the trouble has ceased.

The writer desires to state that invariably the producer has made an effort to correct the condition once he has been convinced that the difficulty has been one involving the manufacturer. However, this effort on the part of the manufacturer is all post-mortem.

It would seem that a great deal of this trouble could have been eliminated had the manufacturer taken full recognition of the value of scientific control methods in reference to the analyses and testing of the clays and the manufacture of the product.

HUNT SPILLER MFG. CORPN.
BOSTON, MASS.

REFRACTORIES FOR FLAT ARCHES[1]

BY JUSTIN E. HARLOW

ABSTRACT

Arch construction is discussed, describing present method of placing fire clay tile. Tile are suspended on cast iron hangers by means of a tee-shaped slot molded in the top end of each tile, giving room for expansion in every direction. Larger quantities of heat units are released, more intense chemical reactions and there is ample shearing strength and small loss from weight or pressure.

Introduction

This paper is written with the idea of conveying to the reader, in brief, the qualities that seem most desirable in fire-clay tile for use in flat suspended arches.

In flat arch construction, the tile are suspended on cast iron hangers by means of a tee-shaped slot, molded in the top end of each tile. Thus, each tile hangs as a separate unit, free to expand in every direction. In the old curved or sprung arch, each brick or unit was held in place by the pressure due to the weight of the arch on each other, the side thrust being taken up by iron buckstays and steel rods. In the flat arch any side expansion or thrust is taken up by a layer of dry asbestos. The construction of the suspending members makes it very easy to thoroughly ventilate the top of the tile by currents of air. This prevents the tile from becoming soaked with heat, softening and deteriorating rapidly under the action of ash slag and corrosive gases.

In the matter of service, efficient operators release far larger quantities of heat units under the arches in a given time than formerly. The chemical reactions are the same as the refractory man has always encountered, but probably more intense because of the greater quantities. Thus, the changed form of furnace roof and the undivided attention of the arch manufacturer has simplified the problem of the tile man.

[1] Read before the Refractories Division, Pittsburgh Meeting, Feb., 1923.

The tile are not subjected to great weight or pressure. The shearing strength is ample. Owing to the fact that the tile are suspended, it is not necessary to dip them; but they should be buttered to seal the joints to prevent heat penetration. To make a joint that is thin and satisfactory, it is very important that the tile should have flat surfaces and square angles, and be true to dimensions. The tile should be coarse in texture; the flint particles should be sharp and not larger than one-quarter of an inch in the greatest dimension. The tile should be highly refractory and able to withstand temperatures as high as 3000° to 3200°F. They should be burned to a point just short of entire elimination of the initial shrinkage, and by no means vitrified. The color should be a deep cream, and each shipment should be uniform. The writer prefers to see the iron spots just showing. The best material only should be chosen and handled in the manner your experience has found best, especially in such matters as weathering, calcining raw clay, grinding, etc.

155 E. Superior Street
Chicago, Illinois

EFFECTS OF ACCELERATORS AND RETARDERS ON CALCINED GYPSUM[1]

By F. C. Welch

ABSTRACT

Theories on the setting and the effects of accelerators and retarders on calcined gypsum are outlined. Accelerators and retarders as found by the writer and several other investigators are given, with comparative effect and any noticeable advantages or disadvantages of such instruments.

Introduction

Rate of Setting Controllable.—One of the most valuable properties of calcined gypsum is that it can be made to harden or "set" in any predetermined length of time at the will of the user. A dentist taking a plaster cast of a mouth uses material accelerated to set in not more than three minutes; a plasterer working on a large wall may use the same material retarded to set in not less than six hours. The ability to control this property has been taken advantage of commercially, so that nearly all of the calcined gypsum products now sold are accelerated or retarded to satisfy the wishes of the purchaser.

The Chemistry of Setting.—The chemical process of the setting of plaster is still a much mooted question. As far back as 1765 Lavoisier[2] gave the following explanation: "If, after having removed the water of hydration from gypsum by fire, it be returned to it (commonly called gaging the plaster) it takes up the water with avidity, a sudden and irregular crystallization takes place, and the small crystals which are formed becoming confused with one another a very hard mass results."

As all anhydrous salts do not set when taking up water to re-form the hydrate some further explanation is necessary. In 1887 Le Chatelier[3] wrote: "On mixing burnt plaster with water each particle soon becomes surrounded by a layer of a solution which is saturated with regard to the hemi-hydrate but strongly supersaturated with regard to the stable gypsum. Crystallization of gypsum soon begins, either spontaneously or more probably from nuclei which have persisted unchanged throughout the burning process. Growth of the crystals taking place from many neighboring centers, radiating groups are formed, and the interlocking of these is at least one of the causes of the strength of the mass."

Desch[4] says any salt in which the anhydrite is much more soluble than the hydrate will do likewise saying that anhydrous sodium sulphate mixed

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

[2] Lavoisier, *Compt. rend.*, **1765**; *Oeuvres Compl.*, **3**, 122 (1765).

[3] H. Le Chatelier, "Thesede doctorat."

[4] C. H. Desch, "The Setting of Plaster," *Trans. Ceram. Soc.* (Eng.), **18**, 15 (1918).

with a small amount of water, and temperature kept below transition point will set in the same manner as gypsum.

Setting a Colloidal Process.—From an entirely different viewpoint several investigators define the setting of plaster as a colloidal process. Cavazzi[1] claims that calcined gypsum when mixed with water forms a colloidal intermediate gel from which needle-like crystals sprout. Traube[2] agrees with Cavazzi. Cavazzi mixed five grams of $CaSO_4.{}^1/_2H_2O$ in 25 cc. of water at 15°. After five minutes 25 cc. of alcohol was added to the clear filtrate. The salt separated out in a gelatinous form which under the microscope later formed needle-like crystals. Cavazzi claims that this result is in harmony with the theory of P. P. von Weiman. Von Weiman claims that the transition of a compound in the solid state in a super-saturated solution is in the form of needle crystals if the compound is not very soluble. If on the other hand the compound is very soluble it separates out as a colloidal gel. Cavazzi claims the second case to be that of gypsum.

When calcined gypsum sets the volume occupied by the set material is greater than that of the liquid mixture. This property is made use of in molding plasters, etc. Theoretically there should be a contraction in the absolute volume of the material:

Specific gravity		Formula weight		
$CaSO_4.{}^1/_2H_2O$	= 2.62	$2CaSO_4.H_2O$	= $290H_2O$	= 18
$CaSO_4.2H_2O$	= 2.32	$CaSO_4.2H_2O$	= 172	

volume before setting $\frac{290}{2.62} + \frac{3 \times 18}{1} = 164.6$; volume after setting $\frac{2 \times 172}{2.32} = 148.1$

The supporters of the colloidal theory of setting attribute this expansion to the separation of crystals from the coagulated gel, while Desch claims it is due to the pushing apart of the crystals of $CaSO_4.2H_2O$. Davis[3] after studying the setting of calcined gypsum under the microscope says that at first an orthorhombic modification of $CaSO_4.2H_2O$ is formed which then changes to a monoclinic form. He attributes the expansion to the above change.

Means of Controlling Rate of Setting.—While a great many substances have the ability to accelerate or retard the setting of calcined gypsum trade practice has pretty generally adopted the use of a few accelerators, gypsum, alum, and zinc sulphate, and one retarder, a packing house product similar to glue and of indefinite composition. It is known to the trade as "retarder."[4]

[1] A. Cavazzi, *Koll. Zeit*, **12**, 196 (1913).

[2] J. Traube, *Koll. Zeit.*, **25**, 62 (1919).

[3] W. A. Davis, "The Nature of the Changes Involved in the Setting of Plaster of Paris," *Soc. Chem. Ind. Jour.*, **26**, 727 (1909).

[4] U. S. patents, Nos. 1,106,777 and 1,308,644.

Some physical factors,[1] such as per cent mixing water, temperature of mixing water, amount of stirring, size of particles, age after calcining, and age after grinding, have an effect on the time of set. All seem agreed that a decrease in mixing water increases the time of set. However, there is a difference of opinion as to the effect of the temperature of the mixing water. Ostwald shows that freshly calcined $CaSO_4.{}^1/_2H_2O$ sets more rapidly than the same material aged and that the grinding of the aged material hastens the time of set.

This Investigation

Purpose.—It is the purpose of the present paper to give a summary of the effects of admixtures on the time of set of $CaSO_4.{}^1/_2H_2O$ in relation to the amount of the admixture required, and advantages or disadvantages of such admixtures for certain desired effects. Calcined gypsum is very sensitive to the effect of some accelerators and retarders, and in some cases both the hardening action and end product are quite different than in others, even though the setting has been retarded the same amount in each case. For instance, a dense hard product might be desired. By mixing with a 2% solution of gum arabic the plastic mixture might be worked about 35 minutes, and a denser, harder product obtained. However, for use as pottery plaster this would not be satisfactory, as even though a harder product would be very desirable the absorption is lowered.

Determination of Rate of Setting

Vicat Needle Method.—The setting of calcined gypsum is not an instantaneous reaction; the paste of calcined gypsum and water first thickens, then solidifies and finally becomes hard. The time of set is usually measured by the Vicat needle.[2] To study the behavior of accelerators and retarders, it is desirable to be able to plot a curve showing the relation between the development of set and the time. The Vicat needle permits of the determination of only one point on such a curve. It was therefore abandoned in favor of the "time-temperature" and the solubility methods. The progress of the reaction was followed by frequent microscopic examinations, and the degree of hardening finally attained was indicated by measurement of the tensile strength of the material when seven days old.

[1] F. F. Householder, *Jour. Amer. Ceram. Soc.*, **1** [8], 578 (1918); W. Ostwald and P. Wolski, "Contributions to the Dispersoid and Colloid Chemistry of Plaster," *Koll. Zeits.*, p. 78 (1920); C. H. Kerr and R. J. Montgomery, "Influence of Variations in Water Addition, Lime Addition and Temperature on Setting of Plaster of Paris," *Trans. Amer. Ceram. Soc.*, **18**, 180 (1916).

[2] W. E. Emley, "Measurement of Time of Set of Calcined Gypsum," *Trans. Amer. Ceram. Soc.*, **19**, 573 (1917); "Tentative Methods of Test for Gypsum and Gypsum Products," *A. S. T. M.*, C26–21T.

Time-Temperature Method.—The "time-temperature" method has been described in a previous paper by Emley.[1] Briefly, it comprises measuring the temperature of a mixture of calcined gypsum and water at different intervals of time. The setting reaction is accompanied by an evolution of heat, which with proper precautions is indicated by a rise in temperature. However, the mixture ceases to be workable long before the setting reaction has reached completion, so that, while this method may be taken to indicate the progress toward complete reaction, it cannot be used to measure the "time of set," *i. e.*, the time at which the material is no longer workable. Typical "time-temperature" curves are shown in Fig. 1. From these curves it will be noticed that immediately after mixing there is a rise in temperature and later a still greater rise. In some cases a slight drop in temperature was noticed after the first rise but in

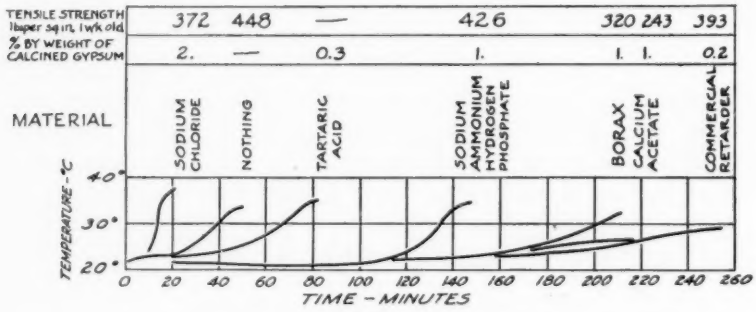

FIG. 1.

other cases this was not noticeable. Canals[2] claims that there is (1) a rapid rise due to hydration (2) a drop due to solution of the gypsum (3) a rise due to crystallization.

Solubility Method.—The solubility method is based upon the amount of gypsum or $CaSO_4.{}^1/_2H_2O$ in solution from the time of mixing to the time when the mixture is no longer workable. As $CaSO_4.{}^1/_2H_2O$ is much more soluble than gypsum it seems that in the beginning the concentration of $CaSO_4$ would be greatly in excess of the amount of gypsum in a saturated solution.[3] As the $CaSO_4.{}^1/_2H_2O$ changes to $CaSO_4.2H_2O$ a supersaturated solution of the $CaSO_4.2H_2O$ is formed. From the curves in Fig. 2, it would appear that the $CaSO_4$ in solution reaches a maximum in a few minutes, then decreases as the time of setting approaches, which seems to show that $CaSO_4.2H_2O$ crystallizes more rapidly than the $CaSO_4.{}^1/_2H_2O$ dissolves.

[1] *Ibid.*

[2] E. Canals, "Action of Some Chemical Substances on the Duration of the Setting of Plaster," *J. Pharm. Chem.*, **14**, 33 (1916).

[3] C. Marignac, *Arch. Sci. Phys. Nat. (Geneva)*, **48**, 120 (1873).

The presence of a foreign material in solution or suspension in the water may increase or decrease the solubility, and therefore the rate of solution of the $CaSO_4{}^1./_2H_2O$. It may increase or decrease the solubility of the $CaSO_4.2H_2O$, thereby elevating or depressing the degree of supersaturation necessary to start crystallization. Or, it may have an effect peculiar to the foreign material. On the above basis Rohland[1] claims that generally substances increasing the solubility of the hemihydrate are accelerators, while substances decreasing the solubility are retarders. Desch and Canals agree with this theory. Traube holds that the setting of the calcined gypsum is due to the coagulation of the gypsum gel, which is accelerated by the addition of electrolytes and retarded by colloids. The acceleration of salts is greatest with the univalent cation with a secondary effect of the anion. The bivalent cation has a lesser accelerating effect and the quadrivalent cation has a retarding effect.

It has been pointed out that contrary to Rohland's theory many sulphates have an accelerating effect, also that $NH_4C_2H_3O_2$ has a retarding effect. Likewise, according to Rohland himself some substances such as NaCl which increase the solubility of $CaSO_4$ in solution have an accelerating effect in dilute solutions and a retarding effect in concentrated solutions of the admixture. Rohland attributes the retarding effect of concentrated solutions of NaCl to the formation of complex ions. Calcium sulphate has a propensity for forming double salts and this might account for the accelerating effect of some sulphates.

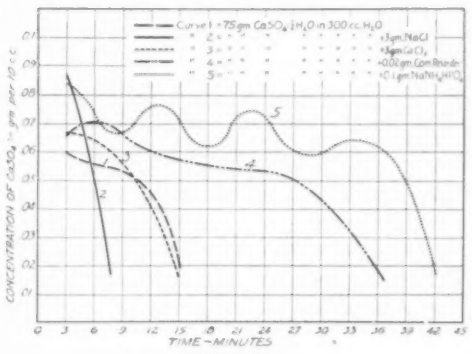
Curve 1 = 75 gm CaSO4.2H2O in 300 cc H2O
+3 gm NaCl
+3 gm CaCl2
+0.01 gm Com'l Retarder
+0.1 gm NaNH4HPO4
CONCENTRATION OF CaSO4 - gm per 10 c.c.
TIME - MINUTES

FIG. 2.

As the result of a large number of experiments conducted at the Bureau, though the effects of admixtures seemed in general to conform to both the above theories, exceptions were found in each case. For instance, if salts that increase the solubility of calcium sulphate in solution accelerate why does ammonium acetate retard the set? If the acceleration is due to the electrolytic effect of the cation of the admixture with a smaller secondary effect of the anion why do soluble phosphates retard the set? Of course as Rohland says a metathetical reaction might take place with the formation of complex ions. Also the formation of double salts may have a decided effect on the time of set.

[1] Rohland, *Zeits. für Elek.*, **14**, 421 (1908).

No explanation of the above effects will be attempted at this time. Though much work has been done on the effects of accelerators and retarders due to the increasing or decreasing of the solubility of the calcium sulphate, no really broad research has been attempted on the basis of the colloidal theory.

In this paper a large number of accelerators and retarders as found in the present work and lists by other investigators will be given. We have endeavored to classify them with respect to their effectiveness and to give any outstanding advantages or disadvantages of such substances.

Accelerators

1. Certain inorganic salts seem to increase the solubility of calcium sulphate in solution. They also accelerate the "time of set." Such accelerators are soluble halides and nitrates.

2. Another type of accelerator is one having the same crystal form as gypsum. The presence of such a material would tend to promote crystallization without requiring the usual degree of supersaturation. Gypsum itself is an example of this type of accelerator.

3. Water glass, if used in large percentages, causes a hardening immediately upon addition. While this can hardly be called setting, it has been found useful along other lines.

Retarders

1. Commercial "retarder," glue, casein, and tannic acid, are the most effective retarders. Small amounts are required in each case. For instance, 0.2% of commercial retarder will increase the time of set two and one-half to three hours. It is believed that such substances act as protective colloids.

TABLE I

ACCELERATORS AND RETARDERS[1]

NaCl	dilute	accelerator	Na_2SO_4	dilute	retarder
	concentrated	retarder		concentrated	accelerator
KCl		accelerator	$(NH_4)_2SO_4$	dilute	retarder
KBr		accelerator		concentrated	accelerator
KI		accelerator	$MgSO_4$	dilute	retarder
NH_4Cl		accelerator		concentrated	accelerator
NH_4F		accelerator	$Al_2(SO_4)_3$	concentrated	accelerator
$CaCl_2$		retarder	$Na_2Si_2O_3$		accelerator
$MgCl_2$		accelerator	HCl		accelerator
$NaNO_3$		accelerator	HNO_3		accelerator
KNO_3		accelerator	H_2SO_4		accelerator
NH_4NO_3		accelerator	C_2H_5OH		retarder
$Mg(NO_3)_2$		accelerator	$C_{12}H_{22}O_{11}$		accelerator

[1] Rohland, *loc. cit.*

2. Alcohol, sugar, and soluble citrates decrease the solubility of the calcium sulphate and retard the time of set. If the "time of set" is affected by a decrease or increase of the solubility of the calcium sulphate in solution these may be considered as the retarders corresponding to the accelerators of group I.

3. Certain substances have what appears to be individual effects. Calcium acetate, for example, changes the crystal form of the gypsum in such a way as to decrease the strength of the set material. Soluble phosphates act as retarders, but instead of giving a slower end effect as most retarders, they give a very rapid rise in temperature as accelerating materials. (See "time-temperature curves.")

Soluble calcium salts and soluble sulphates (except gypsum) may either retard or accelerate the "time of set." Though at times there is a retardation it is not enough to be of practical value. Some are very effective as accelerators dependent to an extent on the amounts used.

Relation of Degree of Retardation to Other Properties

During the course of this investigation some interesting observations were made as to the relation between the degree of retardation and other properties of calcined gypsum.

Tensile Strength.—Acceleration results in the formation of smaller crystals with, consequently, a slight lessening in the tensile strength. The total effect, however, is practically negligible.

Hardness.—Retarders have a decided weakening effect. A certain amount of water is essential for the proper hardening of calcined gypsum. More water than is thus required is always added in order to properly mix the material for use. But if the set is delayed too long, some of this water is lost by evaporation, and some is removed from the field of action by rising to the top of the mold. There is also the possibility that organic colloidal retarders may coat some of the grains of calcined gypsum and prevent the water from reaching them. The net result is a loss of strength.

Shrinkage.—The tendency of retarded calcined gypsum to settle out before it hardens has a decided influence on the shrinkage of a casting. Unretarded calcined gypsum expands when it sets, a fact familiar to everyone. But if the same material is heavily retarded there is a shrinkage from the original volume of the plastic mixture. In this case you may get a harder, denser material but it would not be suitable as a casting plaster.

Heating.—Canals says that in orthopedic plasters the addition of alcohol to the mixture reduces the amount of heat given off by the setting of the plaster. From the "time-temperature" curves it will be noticed that the rise in curve due to heat of crystallization is slower for retarded mixtures than unretarded. In the above case, therefore, the temperature rise would be less due to the slower production of heat. By the addition

TABLE II

ACCELERATORS AND RETARDERS[1]

	Time of set, minutes
10 gm. calcined gypsum + 7 ccm. H_2O	22 25 26 24
10 gm. calcined gypsum + 7 ccm. 0.5 normal K_2SO_4	3.5 4
10 gm. calcined gypsum + 7 ccm. 0.5 normal KCl	4.5 4
10 gm. calcined gypsum + 7 ccm. 0.5 normal KBr	4
10 gm. calcined gypsum + 7 ccm. 0.5 normal KNO_3	4 4.5
10 gm. calcined gypsum + 7 ccm. 0.5 normal $KClO_3$	5
10 gm. calcined gypsum + 7 ccm. 0.5 normal KCNS	5
10 gm. calcined gypsum + 7 ccm. 0.5 normal $K_2Cr_2O_7$	5
10 gm. calcined gypsum + 7 ccm. 0.25 molar $K_4Fe(CN)_6$	6.5
10 gm. calcined gypsum + 7 ccm. 0.25 normal $K_2SO_4Al_2(SO_4)_324H_2O$	6.5 7
10 gm. calcined gypsum + 7 ccm. 0.5 normal Na_2SO_4	5.5
10 gm. calcined gypsum + 7 ccm. 0.5 normal $LiSO_4$	9
10 gm. calcined gypsum + 7 ccm. 0.5 normal $AgNO_3$	8
10 gm. calcined gypsum + 7 ccm. 0.05 normal $TlNO_3$	9
10 gm. calcined gypsum + 7 ccm. 0.1 normal $TlNO_3$	4
10 gm. calcined gypsum + 7 ccm. 0.5 normal $N(C_2H_5)_4Cl$	27
10 gm. calcined gypsum + 7 ccm. 0.5 normal $BaCl_2$	22
10 gm. calcined gypsum + 7 ccm. 0.5 normal $CaCl_2$	16
10 gm. calcined gypsum + 7 ccm. 0.5 normal $CdSO_4$	9
10 gm. calcined gypsum + 7 ccm. 0.5 normal $ZnSO_4$	12
10 gm. calcined gypsum + 7 ccm. 0.5 normal $CaSO_4$	11
10 gm. calcined gypsum + 7 ccm. 0.5 normal $NiSO_4$	13
10 gm. calcined gypsum + 7 ccm. 0.5 normal $CuSO_4$	9
10 gm. calcined gypsum + 7 ccm. 0.5 normal $CuCl_2$	14
10 gm. calcined gypsum + 7 ccm. 0.5 normal $Cu(NO_3)_2$	15
10 gm. calcined gypsum + 7 ccm. 0.5 normal $SnCl_2$	11
10 gm. calcined gypsum + 7 ccm. 0.5 normal $Hg(CN)_2$	22
10 gm. calcined gypsum + 7 ccm. 0.25 normal $ThCl_4$	65
10 gm. calcined gypsum + 7 ccm. 0.5 normal $ThCl_4$	less than 3 hr.
10 gm. calcined gypsum + 7 ccm. 0.5 normal HCl	12
10 gm. calcined gypsum + 7 ccm. 0.5 normal $H_2C_2O_4$	12
10 gm. calcined gypsum + 7 ccm. 0.5 normal H_2SO_4	11
10 gm. calcined gypsum + 7 ccm. 0.5 normal CCl_3COOH	22
10 gm. calcined gypsum + 7 ccm. 0.5 normal $H_2C_4H_4O_6$	22
10 gm. calcined gypsum + 7 ccm. 0.5 normal H_3BO_3	28
10 gm. calcined gypsum + 7 ccm. 0.125 normal CCl_2HCOOH	34
10 gm. calcined gypsum + 7 ccm. 0.5 normal H_3PO_4	32
10 gm. calcined gypsum + 7 ccm. 0.5 normal $CClH_2COOH$	less than 40
10 gm. calcined gypsum + 7 ccm. 0.5 normal CH_3COOH	150
10 gm. calcined gypsum + 7 ccm. 0.5 normal C_2H_5COOH	180
10 gm. calcined gypsum + 7 ccm. 0.5 normal $COOH.CH_2C(OH)$	240–300
10 gm. calcined gypsum + 4 ccm. 0.5 normal KCl	almost at once
10 gm. calcined gypsum + 5 ccm. 0.5 normal KCl	2.5
10 gm. calcined gypsum + 7 ccm. 0.5 normal KCl	4 4.5
10 gm. calcined gypsum + 9 ccm. 0.5 normal KCl	4.5
10 gm. calcined gypsum + 11 ccm. 0.5 normal KCl	5 5.5

[1] J. Traube, *loc. cit.*

	Time of set, minutes
10 gm. calcined gypsum + 13 ccm. 0.5 normal KCl	6
10 gm. calcined gypsum + 15 ccm. 0.5 normal KCl	after 40 still not set
10 gm. calcined gypsum + 7 ccm. saturated KCl solution	12
10 gm. calcined gypsum + 7 ccm. 0.5 normal KCl solution	4.5
10 gm. calcined gypsum + 7 ccm. 0.25 normal KCl solution	5.5
10 gm. calcined gypsum + 7 ccm. 0.125 normal KCl solution	9
10 gm. calcined gypsum + 7 ccm. 0.0625 normal KCl solution	19
10 gm. calcined gypsum + 7 ccm. 2 normal KCNS	8 8.5
10 gm. calcined gypsum + 7 ccm. 1 normal KCNS	6
10 gm. calcined gypsum + 7 ccm. 0.5 normal KCNS	5
10 gm. calcined gypsum + 7 ccm. 0.25 normal KCNS	8
10 gm. calcined gypsum + 7 ccm. 0.125 normal KCNS	11
10 gm. calcined gypsum + 7 ccm. 0.0625 normal KCNS	13

TABLE III

ACCELERATORS AND RETARDERS[1]

Name of admixture	Time of set, minutes: Plaster alone	Plaster plus one gm. of admixture
Potassium Salts		
K_2SO_4	28	7
KCl	26	7
KNO_3	28	10
KBr	26	9
KI	26	13
K_2CO_3	28	22
K_2SiO_3	29	39
Sodium Salts		
NaCl	26	9
Na_2SO_4	23	13
$NaNO_3$	31	15
NaBr	26	14
NaI	26	15
Na_2HPO_4	28	22
Na_2CO_3	28	30
Na_2SiO_3	29	95
$Na_2B_4O_7 . 10H_2O$	28	300
Ammonium Salts		
$(NH_4)_2SO_4$	28	9
NH_4Cl	28	11
NH_4NO_3	28	13
NH_4Br	28	16
NH_4I	28	17
Acids		
H_2SO_4	28	11
HCl	28	18
HNO_3	28	19
H_3BO_3	28	30
Bases		
KOH	28	12
NaOH	28	14
NH_4OH	28	28
$Ba(OH)_2$	28	29
Other Inorganic Admixtures		
$MgSO_4$	28	19
$FeSO_4$	28	19
$CaSO_4$	28	22
CaO	28	30
MnO_2	28	27
SiO_2	29	29
BaS	30	30
Organic Substances		
Sugar { 5 cc. H_2O plus 5 cc. of syrup	28	35
Glycerine { 55 cc. H_2O plus 5 cc. glycerine	28	37
Alcohol { 55 cc. H_2O plus 5 cc. alcohol	28	36
Soap (0.5 gm.)	25	19
Soap (5 gm.)	25	10

[1] E. Canals, *Jour. Pharm. Chem.*, **14**, 33(1916).

TABLE IV

RESULTS OBTAINED AT BUREAU

Admixture	Amount of admixture	Calcined gypsum	Water	Temperature difference from time of mixing to end of final rise, in degrees	Time from mixing to end of final rise in time-temperature curve, in minutes
		100	60	14	53
		100	70	13.5	59
KFFH	0.5 gm.	100	70	22	25
NaCl	0.5 gm.	100	70	19.5	38
NaCl	2.0 gm.	100	70	17.8	21
CaS	1 gm.	100	70	15.5	44
K_2SO_4	0.5 gm.	100	70	17.7	50
K_2SO_4	8 gm.	100	70	17.4	48
$BaSO_4$	0.5 gm.	100	70	16.5	57
$Ca(OH)_2$	0.5 gm.	100	70	17.5	49
$CaCl_2$	0.5 gm.	100	70	17.7	81
$CaCl_2$	2 gm.	100	70	18.2	51
$CaCl_2$	8 gm.	100	70	20.9	43
$Al_2(SO_4)_3$	0.5 gm.	100	70	19.6	53
$NH_4C_2H_3O_2$	0.5 gm.	100	70	17	64
$Ca(C_2H_3O_2)_2$	0.5 gm.	100	70	11.8	113
$Ca(C_2H_3O_2)_2$	1.0 gm.	100	70	8.8	200
$Ca(C_2H_3O_2)_2$	2.0 gm.	100	70	4.3	340
					still soft
$H_2C_2O_4$	1 gm.	100	70	17.1	70
CH_3OH	5 ccm.	100	70	13.9	78
$NaNH_4HPO_4$	0.5 gm.	100	70	17.4	102
$NaNH_4HPO_4$	1 gm.	100	70	15.2	150
$NaNH_4HPO_4$	2 gm.	100	70	20.8	86
$NaNH_4HPO_4$	4 gm.	100	70	38.2	153
$COOH.CH_2C(OH)$	0.2 gm.	100	70	20.1	66
$COOH.CH_2C(OH)$	.5 gm.	100	70	11.2	165
$COOH.CH_2C(OH)$	.8 gm.	100	70	16.9	83
$H_2C_4H_4O_6$	.1 gm.	100	70	15.9	84
$H_2C_4H_4O_6$	.15 gm.	100	70	15.7	98
$H_2C_4H_4O_6$	.3 gm.	100	70	18.7	91
$H_2C_4H_4O_6$	4 gm.	100	70	16.3	59
$Na_2B_4O_7$	0.5 gm.	100	70	16.5	93
$Na_2B_4O_7$	1 gm.	100	70	17.7	222
$Na_2B_4O_7$	2 gm.	100	70	41.1	262
Commercial retarder	0.066 gm.	100	70	14.9	92
Commercial retarder	.132 gm.	100	70	12.8	185
Commercial retarder	.198 gm.	100	70	8.1	254
Commercial retarder	.264 gm.	100	70	5.3	315
HPO_3	.2 gm.	100	70	7.0	210
$NaPO_3$	.1 gm.	100	70	9.4	232
Tannic acid	.1 gm.	100	70	7.4	281

Other accelerators: KCl, NH_4Cl, $MgCl_2$, $NaNO_3$, KNO_3, NH_4NO_3, KI, and $CaSO_4.2H_2O$.

of much alcohol and thereby a lower solubility of the calcium sulphate it seems natural there would be less heat from crystallization.

From a study of the "time-temperature" curve of calcined gypsum containing a small amount of soluble phosphate it will be noticed that there is a retardation of the beginning of crystallization and then very rapid crystallization. This was thought to be useful in work requiring such properties, as in the dental trade, and has since proved to be of value.

Effect of Additions on Hardened Product

The after effect on hardened plaster by the addition of accelerators and retarders is very important. Salts of sodium, magnesium, and iron have a tendency to cause efflorescence on the set material, no doubt due to the formation of their corresponding sulphates. This may not be serious where small quantities of such salts are used but is liable to give trouble if large quantities are present. Acids and acid salts cause a swelling and formation of large pores in the plaster. As practically all commercial calcined gypsums contain some calcium carbonate, the trouble probably is due to the liberation of the carbon dioxide.

NOTE: Acknowledgment is made to W. E. Emley, whose supervision of this work has contributed in a large measure to the value of results obtained.

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Vol. 2 **November, 1923** **No. 11**

Author Index[1] to Abstracts for November

Author	Number of abstract
Anderson, H. F.	56
Anon	10, 67, 68, 70, 71, 72, 76, 77, 104, 107, 108, 115, 116, 117, 124, 127
Bailey, C. F.	120
Bawtree, A. E.	2
Bergdahl, B.	106
Berry, H.	20
Bigot, A.	44
Blacker, J. F.	100
Bowles, O.	18
Braun, W.	123
Brissaud, A.	16
British Thomson-Houston Co., Ltd.	66
Brookes, E.	101
Buckley, L. C.	102
Burchartz, H.	12, 74
Cadwell, C. A.	113
Call, B. G.	109
Chapman, W. B.	46
Cordery, F.	22
Corl, R. M.	59
Deguide, C.	130
Delany, J. H.	60
Demongeot, M. A.	57
Denney, G. C.	93
Elliott, C.	4
Ennos, F. R. and Sutcliffe, R.	144
Ferolite, Ltd., and H. B. Clapp	84
Filon, L. N. G., and Harris, F. C.	48
Fukudo, Y.	25
Funk, W.	98
Fuwa, K.	30, 31, 32, 33, 34, 35
Gibson, A. H., Lea, F. C., and Griffiths, E.	27
Glasenapp, M. von	19
Goslich	8, 9
Gravely, J. S.	29
Grün, R., and Biehl, K.	142
Hagaman, M.	103
Halle, B.	105
Hardoncourt, A.	75
Heinel, C.	99
Heiser, A.	114
Hitchcock, H. K.	52
Hodkin, F. W., and Turner, W. E. S.	47
Howard, H.	131, 132
Igawa, M.	133
Irons, G. E.	121
Jacobus, D. S.	23
Jones, D., and Emery, W.	79
Jones, W. R. R.	80
Kato, T.	38
Kirk, R. E.	17
Klein, A. S.	6
Knothe, W. J.	42
Kondo, S.	73
Koyama, K., Ishida, T. and Nakamura, Y.	94
Krak, J. B.	43
Kühl, H.	15
Ladoo, R. B.	128
Lecrenier, A.	50
Lindsay, R. F.	81
Liptak, M.	86, 87, 88, 89, 90, 91
Lowry, T. M., and McHatton, L. P.	1
MacLellan, A. D.	110
Miller, W. J.	62
Mitchell, S. A.	119
Moldenke, E.	85
Mori, J.	36
Mullen, J. I.	111
Musiol, C.	26
Nagaya, S.	5
Nihoul, A., and Clerc, C.	129
Okazawa, T.	136
O'Neill, F.	54
Owens, T. S.	61
Parravano, N., and del Turco, C. R.	137
Passow, H.	7
Prat, L.	122
Proctor, C. H.	41
Rakusin, M. A.	138
Reutlinger, E.	95
Richmond, H. D.	49
Riddle, F. H.	97
Rie, E.	140
Rieke, R.	83
Sato, D.	126
Sauvageon, M.	112
Schuen, W.	45
Schultes, W.	141
Schwarz, R., and Brenner, A.	139
Scott, G. C.	63
Shorkey, F. A.	143
Sinnatt, F. S., Owles, A. B., and Simpkin, N.	82

[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of *Chemical Abstracts* by coöperative agreement.

Author Index to Abstracts for November (*Continued*)

Author	Number of abstract
Soc. Anon. quartz et silice	64, 65
Soubier, L. D.	53
Springer, L.	39
Stahl, C. J.	40
Stevens, E. P.	118
Suzuki, T.	125
Swientoslawski, W.	146
Taggart, A. F., and Gaudin, A. M.	145
Takahashi, S.	37
Takamatsu, T. and Kuwayama, M.	78
Takita, I., and Wataya, M.	147
Tamman, G., and Pape, W.	135
Taylor, R. L.	21
Tippman, F.	13, 14
Trillich, H.	3
Uchida, T., and Arimoto, K.	24
Van Nieuwenburg	51
Vogel, O.	28
Wattebled, M. F.	69
West, C. J.	134
White, G. N.	96
Wikoff, A. G.	11
Wilcox, A. C.	58
Willett, A. H.	92
Willetts, H. G.	55

Art

1. Further experiments on the measurement of color. T. M. LOWRY AND L. P. MCHATTON. *J. Oil Colour Chem. Assoc.*, **5**, 351–3(1922).—The densities of a number of Lovibond glasses were previously measured (*Ceram. Abs.*, **1** [10], 256(1922); *ibid.*, **2** [3] 47(1923)), and curves plotted to show the relationship between density and serial numbers of a complete series of glasses. These curves were almost linear, but when extended they cut the axis of 0 density at a point on the scale of numbers corresponding to —2 instead of 0. This has been found to be due to the fact that filters of equal density at the wave-length of max. absorption of light are not equal when examd. with white light. F. A. W. (*C. A.*)

2. Record of color research during 1922. A. E. BAWTREE. *J. Oil Colour Chem. Assoc.*, **5**, 353–6(1922).—A brief description of improvements made to the color circle used in the Bawtree colorimeter (cf. preceding abstract.) F. A. W. (*C. A.*)

3. Color designation. HEINRICH TRILLICH. *Farben-Ztg.*, **28**, 1001–2(1923).—See also *Ceram. Abs.*, **2** [4], 70(1923). F. A. W. (*C. A.*)

Cement, Lime and Plaster

4. Plaster of Paris technology. C. ELLIOTT. *Chem. Trade and Chem. Eng.*, **72**, 725(1923).—(1) *The effect of ht. on gypsum.* The greater part of the plaster made today is obtained by grinding the rock to a fine powder and calcining it in suitable vessels by indirect heating. In Eng. finely-ground gypsum is spread to a depth of about 6 in. in large open pans (15 to 22 ft. in diam.) provided with stirrers to agitate the mass. About 3 or 4 T. of gypsum are calcined at a time, the complete opern. from filling to emptying taking 3 to 4 hrs. In the U. S. and Canada finely ground gypsum is calcined in large cylindrical vessels with cast-iron dished bottoms, the whole being set in brickwork and heated by a fur. placed underneath. (2) *The first and second boiling periods.* As the ground material is heated the temp. rises until at a certain point the evoln. of steam begins and this steam in rising through the material gives it every appearance of boiling. The "boiling" period represents the loss of about $^3/_4$ of the combined water, and while this is being driven off the temp. remains constant, all the ht. being utilized in vaporizing the liberated water. At the end of this "first boil" the material is mainly $CaSO_4.^1/_2H_2O$, or plaster of Paris. The temps. necessary to convert gypsum into $CaSO_4.^1/_2H_2O$ and also $CaSO_4.^1/_2H_2O$ into $CaSO_4$ depend entirely on the circumstances. The lowest temps. obtained exptly. in the lab. are 98°C and 107°C respectively, but as the time necessary is very great, temps. considerably above these are employed on the large scale in order to increase the speed of reaction. Commercially the "first boil" varies between 108°C and 130°C, while the "second boil" varies between 160°C

and 200°C. (3) *Direct heating methods.* The outside layers are protected by these parts and the ht. only slowly penetrates; the temp. at which any particular layer parts with $^3/_4$ of its water to form $CaSO_4.^1/_2H_2O$ is found approx. 100°C. This very steep temp. gradient from surface to center makes it possible to have anhydrous calcium sulphate at a dull red heat on the surface while a few mm. from the surface either $CaSO_4.^1/_2H_2O$ or even unchanged gypsum may exist. In both stationary kilns and rotary calciners the material after direct heating for a period is allowed to cool slowly, the heat absorbed by the lump slowly calcining the inner portions. Thus in kilns the heating may be 8 to 10 hrs. and the cooling 12 to 15 hrs., while in rotary kilns with smaller lumps, contact with the gases may only be for 10 to 20 mins. with cooling and "cooking" in large bins for a much longer period. (4) *Flooring and hard-finish plasters.* The most reliable information on this particular plaster is given by M. GLASENAPP. Flooring plaster consists of a mixt. of a hard, sintered, cryst. modification of the anhydrite with small quantities of a segregated, vitreous, basic anhydrite holding lime in solid soln. Normal flooring plaster is best made at about 900°C and as the temp. is raised above this up to 1300° (and over) the material becomes coarser in structure and harder with increasing amts. of the basic constituent. (4) *The noncondy. of gypsum.* This table shows condy., B.t.u., transmitted per hr. per sq. ft. of surface per degree F diff. of temp.:

No. inches		B.t.u.	No. inches		B.t.u.
3	Solid gypsum slab.....	0.25	3	Concrete slab, 1–3–5 mixt.....	0.75
4	Solid gypsum slab.....	.20			
5	Solid gypsum slab.....	.19	2½	Concrete slab.....	.85
6	Solid gypsum slab.....	.18	2	Yellow pine planks.....	.38

In above table, each type of material was covered with felt roofing material, but other expts. show that the corresponding fig. for 3 in. solid gypsum is 0.4 B.t.u., for 3 in. cinder concrete 1.2, and for stone concrete 2 B.t.u., when these were tested without covering. (5) *Fire-resistance of gypsum.* Expts. made on large gypsum blocks (Underwriters' Labs. in the U. S.); block used 6 in. thick, subjected to varying temps. for various temps. for various times:

4 HRS. AT 2200°F		2 HRS. AT 1900°F	
Distance from surface, inches	Temp., °F	Distance from surface, inches	Temp., °F
1	1980	1	950
2	1255	2	220
3	315	3	210
4	223	4	180
5	211	5	140
6	208	6	130

It will be noted that in the first case, although on one side the temp. of 2200°F had been maintained for 4 hrs., yet at the end of that period the temp. of the other side was only 208°F; that is, only 9½% of the heat on the fur. side had penetrated the block, while in the second case the amt. was only 6.8%. It is assumed that 10 foot lengths of gypsum, clay tile, and concrete are heated from 70°F to 1700°F by fire, then the resulting increase in length by fire would be approx.:

Gypsum.....	0.158 in.
Clay tile.....	.590 in.
Concrete.....	1.180 in.

Obviously this slight expansion in the case of gypsum is not sufficient to cause injury to either the material itself or the structure. O. P. R. O.

5. On the crushing strength of concrete and proportion of its materials. SHUKICHI NAGAYA. *J. Jap. Cer. Assoc.*, **366,** 75–9(1923).—The paper may be regarded as summary of author's repts. which have been published since 1918. 1. *Amt. of water.* (*a*) Amt. of water used in concrete must be expressed in per cent of total amt. of cement and sand. (*b*) Excess of water reduces the crushing strength; the decrease per vol. per cent of water is about 100 lbs. per sq. in. for Port. cement-sand-gravel concretes. (*c*) The excess of water is the most usual cause of air cracking. The author has observed cracking due to blowing of cement in concrete construction only once in his career. (*d*) The effect of excessive water is more serious in concretes with volcanic ashes or diatomaceous earth, as they absorb much water. 2. *Propn. of sand.* The crushing strength of concrete depends chiefly on the nature of its mortar; the effect of varying propn. of gravel is very slight within wide range. Concrete with 1:3 mortar can never be as strong as that with 1:2 mortar. 3. *Aging.* Concrete with a cement which has been stored for 6 months is at least 10–20% weaker than that with fresh one. (Failures in concrete structures frequently owe to an old cement which causes unintimate mixing of materials and also makes the concrete porous.) The author proposes the use of Port. cement without testing. S. K.

6. Upright (lime) kilns. A. S. KLEIN. *Rev. Mat. Constr. Trav. Pub.*, **164,** 100–102 (1923).—Some general remarks on the opern., thickness of bed, size of raw material, massing of material during heating, height of kilns and ventilation. L. N.

7. Free lime in a Portland cement clinker. H. PASSOW. *Zement,* **12,** 143–5 (1923).—Quartz sand acts as an inert material when mixed with a Portland cement clinker. Blast-furnace slag when mixed with the clinker causes an increase in the amt. of free lime formed during the initial hardening. R. F. S. (*C. A.*)

8. Free calcium hydroxide in hardened Portland cement. GOSLICH. *Zement,* **12,** 149–50(1923).—A sample of hardened Portland cement was exposed to moist air for 6 days. It was then dried at 90° and ground to a fine powder. The sample was fractionated by a suspension analysis into the following portions: 1.78% heavier than 2.84 (sp. gr.); 40.72% between 2.84 and 2.7; 25.25% between 2.7 and 2.6; 16.53% between 2.6 and 2.44; 7.81% between 2.44 and 2.23; and 7.93% lighter than 2.23. This latter portion should contain all the free $Ca(OH)_2$, since $Ca(OH)_2$ itself has a sp. gr. of 2.078. The analyses of the fractions show that the lighter portion contains 12% excess CaO. This represents 0.95% of the total cement and indicates that free CaO is not formed during the hardening period. R. F. S. (*C. A.*)

9. How much water is chemically combined in a hardened Portland cement? GOSLICH. *Zement,* **12,** 163–5(1923).—Test specimens were made with 100 g. cement and 26 g. distd. water. These were stored in a moist closet. Samples were analyzed at various intervals from 1 hr. to 28 days after the mixing with water. The combined water was detd. as follows: The samples were powdered and dried to const. wt. at 90–5°. Two g. were ignited to const. wt. The loss in wt. minus the loss due to the volatile matter as previously detd. is the chemically combined water. In one cement 1.63% H_2O had combined at the end of the first hr. The amt. combined gradually increased to 13.36% at the end of 28 days. R. F. S. (*C. A.*)

10. Acid-proof cements. ANON. *Chem.-Ztg.*, **47,** 504(1923).—Water glass is a component of practically all acid-proof cements. Complete drying out and a thorough fixing of the cement after drying are essential. Usually this fixing is carried out with a dil. acid applied in repeated coats. Alkalies are harmful to these cements, and no cement is known equally resistant to both acids and alkalies. W. C. E. (*C. A.*)

11. Manufacture and application of lightweight concrete slabs. A. G. WIKOFF.

Chem. Met. Eng., **28**, 975–6(1923).—A mortar is made with 3 parts of cement, 1 of sand and 7 of a material which is solid at ordinary temp. but melts in hot water. This latter material is formed into pellets before mixing with the cement and sand. The mortar is molded into slabs which are reinforced and allowed to set. After setting the pellet material is removed by heating and steam-distg. The slabs are 24 x 32 x $1^1/_8$ in. and weigh 30 lb. They are porous, strong, and resistant to the effects of heat and steam.
R. F. S. (*C. A.*)

12. The properties of Portland cement. H. BURCHARTZ. *Zement*, **12**, 186–7, 193–5(1923).—A tabulation and discussion of the results of phys. tests on 110 samples of Port. cement. R. F. S. (*C. A.*)

13. Determination of the suitable fineness of grinding of materials used in the manufacture of cement. F. TIPPMANN. *Zement*, **11**, 541(1922); *Chimie et industrie*, **9**, 1187(1923).—Blast 3–4 g. of the material for 10 min. in an old Pt crucible so as to form a completely fused clinker which is evenly colored a blackish green after cooling. Brown, yellow, or even white spots, observable with a magnifying glass, clearly indicate that the material was not ground sufficiently fine. If the temp. is raised above the softening point there are formed fissures having a whitish green color, which might lead to false conclusions. A. P.-C. (*C. A.*)

14. The fine grinding of cement raw mix. F. TIPPMANN. *Zement*, **12**, 150–1 (1923); cf. *C. A.*, **17**, 2484.—Extreme fineness is not necessary for cement raw mix. provided the clinker is thoroughly sintered. R. F. S. (*C. A.*)

15. Fineness of raw mix, strength, and impact test. H. KÜHL. *Zement*, **12**, 155–8, 174–7(1923).—A review and discussion with a bibliography. R. F. S. (*C. A.*)

16. A new application of the electric furnace. Fused aluminous cement. A. BRISSAUD. *Science et industrie*, **6**, 83–6(1922); *Chimie et industrie*, **9**, 1187(1923).—A description of the manuf. of fused aluminous cement in the elec. furnace. Furnaces of 1,000–2,000 h. p. are used, giving 25–40 tons a day. The cement is tapped every 3–4 hrs. Power consumption is 1,000–1,400 kw.-hr. per ton. There is considerable wear of the electrodes, owing to the action of the CO_2 from the limestone, atm. O, and oxides, and mechanical abrasion during charging. (Cf. J. Bied, *Jour. Amer. Ceram. Soc.*, **4** [4], 317(1921); *Ceram. Abs.*, **2** [5], 91(1923); E. Candlot, *C. A.*, **16**, 1845.)
A. P.-C. (*C. A.*)

17. The manufacture of Portland cement from marl. R. E. KIRK. Univ. Minn. Eng. Expt. Sta., *Bull.* **2**, 52 pp.(1923).—Portland cement can be made from marl and clay, of as good a quality as that made from any other raw materials. The origin of marl, its chem. compn., and the quality and quantity available in Minnesota are discussed. Plant operations are taken up in detail. R. F. S. (*C. A.*)

18. An untrodden field in lime research. O. BOWLES. *Concrete* (Mill Section), **23**, 127(1923).—Limes vary greatly in their physical properties and chem. activities such as plasticity, rate of slaking, or rate of settling as milk of lime; these variations in many instances bear no relation to the chem. compn. of the original limestone. A definite relationship undoubtedly exists between the character of the lime and the physical properties of the parent limestone, but little serious effort has yet been made to correlate them. J. C. W. (*C. A.*)

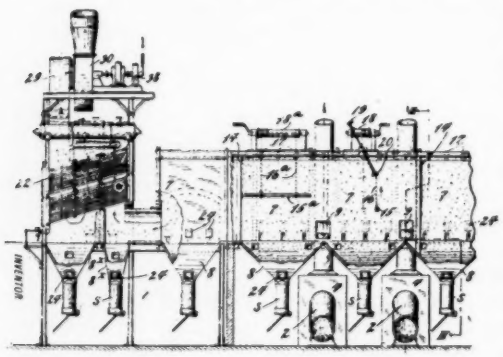
19. Energy of crystallization of calcium sulfate dihydrate, and "regenerated" gypsum. M. VON GLASENAPP. *Zement*, **11**, 365–7(1922).—The complete conversion of 2 $CaSO_4.H_2O$ into the dihydrate requires only a little more than the theoretical amt. of water. In consequence of the increased crystn. pressure the regenerated gypsum has a more flaky structure than the natural mineral and is also notably harder than the latter. J. S. C. I.

PATENTS

20. Artificial stone, cements, etc. H. BERRY. Brit. 189,892, Sept. 13, 1921. Waste slate, coal shale, granite, broken bricks, clinker, slag, or any Al silicate, or sand, quartz, flint, or other form of SiO_2 is powd. and mixed with MgO, and with either tartaric acid or the carbonates, hydrates, or bicarbonates of Na, K, or NH_4, or mixts. of these. 1–2% of sol. silicates may be added to the alk. substances, or the finished product may be soaked in a sol. silicate soln. Traces of Ba or Sr salts, with or without NH_4 salts such as the chloride, sulfate or phosphate may be added, and an addn. of 1–2% of a sol. Mg salt, preferably the sulfate, may also be made. The magnesite is preferably calcined at 300–600° in an atm. of steam, any distillate being collected and added to the compn. A typical compn. consists of powd. slate 85, MgO 10, $^1/_2$ part of Ba compd. 0.5 and $NaHCO_3$ 5 parts. The product may be used for flooring or molded articles, or if mixed with asbestos, slag wool, or the like, as an insulating covering. Cf. *C. A.*, **17**, 2486. (*C. A.*)

21. Building brick and process of making same. ROBERT L. TAYLOR. U. S. 1,462,991, July 24. The process of making building blocks or the like consisting in first crushing ferro manganese slag to a proper consistency, mixing the mass with water to form an intimately associated plastic mixt., holding unitary portions under pressure, and then subjecting the compressed and molded units to steam and drying them, substantially as set forth. A building block or the like composed principally of ferro manganese slag.

22. Manufacture of building blocks and bricks. FRANK CORDERY. U. S. 1,465,115, Aug. 14. As a new article, a building block composed of dried out pulverized slag, Port. cement and magnesium chloride.



23. Cement-kiln system. DAVID S. JACOBUS. U. S. 1,463,363, July 31. App. for treating dust-laden cement kiln gases, comprising a flue arranged to permit a current of dust-laden gases to flow substantially unobstructedly therethrough without substantial change in the general direction of flow in its passage through said flue, said flue having refractory heated side walls exposed to the current of gases for the collection of a caking material, and a plurality of baffles projecting a short distance from each of said side walls at spaced intervals along the length of the flue and adapted to cause eddies in the current to bring different portions of the gases into contact with the side walls, said side walls being accessible for cleaning while the app. is in opern.

Enamel

24. Study of acid-resisting enamels. TOKIJI UCHIDA AND KAZUO ARIMOTO. (The Osaka Indus. Lab.), *Bulletin* **4** [1], 68 pp. (1923).—The influences of variation in the compn. of enamel-frits upon their resist. to sulphuric acid have been detd., starting from standard frits which contain basic flux (Na_2O, $^1/_3Na_3AlF_6$ or PbO), refrac. base ($^1/_2Al_2O_3$, CaO, ZnO, BaO or MgO), acid flux (B_2O_3) and refrac. acid (SiO_2, TiO_2 or ZrO_2) in the ratio of 1.0:0.6::0.5:2.4. The soly. was compared by putting 2 g. of frit with fineness of 900–1000 mesh per sq. cm. in a weighing bottle contg. 10 cc. of 10% sulphuric

acid and by leaving them for 48 hrs. at 20° C under normal press. 1. *Effect of basic fluxes on resist. to acid.* (1) Their effect is practically similar, but soda is better than cryolite or lead oxide. (2) An excess of cryolite causes difficulties in melting as it badly corrodes the pot, while too small propns. make the frit too refrac. The best result is obtained with 0.8 equivalents. 2. *Effect of refrac. base on resist. to acid.* (1) The effect is very marked. The best result is obtained with barium oxide followed by magnesium oxide. Oxides of zinc, aluminium and calcium are detrimental. (2) The series 0–1.0 $BaO.{}^1/_3Na_3AlF_6.0.5B_2O_3.2.4SiO_2$ is least sol. at 0.3BaO. 3. *Effect of acid flux on resist. to acid.* The resist. is reduced by an increase in boric acid. $0.3B_2O_3$ is most suitable; since a smaller content makes the frits too refract. 4. *Effect of refrac. acid on resist. to acid.* (1) The effect is remarkable. Only silica is satisfactory among the 3 acids. (2) The resist. increases as the content of silica rises. 5. *Effect of mutual replacement of base and acid on the resist. to acid.* (1) Expts. on series 1.0–0BaO or MgO. 2.0 $-3.0SiO_2.{}^1/_3Na_3AlF_6.0.5B_2O_3$ show that good frits are obtainable only in some definite ratios of the base and the acid, 0.6BaO or $MgO:2.4SiO_2$ being best for the series. (2) Soly. of series 0.6–1.5 $^1/_3Na_3AlF_6.0.9–0B_2O_3.0.6BaO.2.4SiO_2$ decreased with the content of cryolite. Considering the difficulties caused by its corrosive action on pot, the propn. 1.0 $^1/_3Na_3AlF_6:0.5B_2O_3$ seems to be most suitable. 6. *Production of the best frit.* Since the expts. hitherto described have indicated that Na_2O, B_2O_3, BaO and SiO_2 are most desirable constituents of acid-proof enamels, the authors then started to find their best propn., keeping the ratio of fluxes and refract. oxides at 1.3:3.7 in equivalents and also the contents of soda and boric acid as 1.1 and 0.2 respectively. The best frit thus obtained is $0.3BaO.3.4SiO_2.1.1Na_2O.0.2B_2O_3$. The frit loses only 0.28% in the test, and is quite satisfactory in other respects, such as melting point, burning luster, burning color and adherence to iron. S. K.

25. Study of cast iron enamels. YUTAKA FUKUDO. (The Osaka Indus. Lab.), *Bulletin* **4** [2], 43 pp.(1923).—The process of enameling cast iron ware in single coat is described. 1. *Raw materials used in the expts.* Cast iron pieces contg. 2.51% carbon, 1.99% silicon, 0.10% sulphur, 0.06% phosphorus and 0.34% manganese were employed. Enamel materials were quartz, red lead, cryolite, soda-ash and sodium nitrate. 2. *Effect of cast iron.* Four kinds of cast iron, ranging in the content of carbon from 2.58 to 3.13% gave almost same results for same glazes. 3. *Effect of fusibility of enamel.* 510°C is the most suitable m. p. for the purpose. 4. *Effect of coeff. of expansion.* Expts. with 35 diff. batches show that enamels with expansion-coeff. of 0.0000220–0.0000280 are most suitable. 5. *Effect of opacifier.* Cryolite makes an enamel fragile when it is used in excess of 15%. If stannic acid is used, it should be introduced to an enamel when its frit is ground. 6. *Effect of glazing process and time of firing.* Employing an enamel as $\left\{\begin{matrix} 0.112\ Na_2O \\ 0.337\ PbO \\ 0.551\ {}^1/_3Na_3AlF_6 \end{matrix}\right.$ $\left.\begin{matrix} \\ 1.242\ B_2O_3, \\ 1.526\ SiO_2 \end{matrix}\right\}$ composed of 25 quartz, 20 red lead, 40 boric acid, 10 cryolite and 5 sodium nitrate, the author got the best results when the enamel was fired at 750–770°C for 30–10 secs. after applying its dry powder on hot test pieces, previously heated at above temps. for 2–4 mins., or when the enamel was fired at 800–820°C for 40–10 secs. after applying its powder on hot test pieces which had just been heated at the same temps. for 1–3 mins. 7. *Surface-treatment of cast iron body.* Surface-decarbonization of cast iron prevents the bubbling of enamel. A very excellent result was obtained with test pieces which had been coated with ferric oxide, manganese dioxide or sodium nitrate, placed in a muffle, heated to 850°C and then cooled very slowly. 8. *Colored enamel.* The batch described in 6 gave excellent colored enamels when suitable amts. of colorants had been used. For example, 3 copper oxide, 3 chromium oxide, 3 manganese dioxide and 0.5 cobalt oxide pro-

duce a light sky blue, a dark green, a dark brown and an indigo blue respectively.
S. K.

26. Correct notions on fluoride enamels. CHARLES MUSIOL. *Chimie et industrie*, **9,** 872–87(1923).—A mathematical criticism of the theories of Vogt, Gruenwald, and Mayer and Havas (*Sprechsaal*, **1911,** No. 1) based on the analyses published by these authors. It is shown that F is not volatilized as SiF_4, that when B_2O_3 is present F is probably volatilized as BF_3 (this would require to be confirmed by analysis of the gases evolved), and that Mayer and Havas' results abound in errors, either clerical or analytical. A method is given for calcg. the compn. of the enamel from that of the initial mixt. Seger's formula is worse than useless. The relationship between the various constituents should be studied by means of the centesimal mol. compn.
A. P.-C. (*C. A.*)

27. The effect of enamel on the transmission of heat. A. H. GIBSON, F. C. LEA AND EZER GRIFFITHS. *Repts. Light Alloys Sub. Comm., Advisory Comm. for Aeronautics*, No. **5,** 61–90(June, 1921); *J. Inst. Metals*, **28,** 632.—The rate of flow of heat from a rough cast Al surface to the air or to water is considerably improved if the surface is coated with a smooth enamel. A large no. of tests showed that the best results are obtained with a hard, smooth, stoved enamel, which increases the rate of transmission of heat from a rough cast Al alloy surface to air by 15% and to water by 4 to 8% from cast iron to air by 7% and from steel to air by 2%. No effect is produced on Cu.
H. G. (*C. A.*)

PATENTS

28. Pickling bath for iron. O. VOGEL. U. S. 1,460,395, July 3. A pickling bath for Fe is formed of H_2SO_4 or other acid soln. contg. about 1% quinoline or one of its derivs. to prevent the metal from becoming brittle. (*C. A.*)

29. Removing rust from metals. J. S. GRAVELY. U. S. 1,459,910, June 26. Rust is removed from articles of ferrous metal or Ni-plated ware by treating them with a soln. of NH_4 citrate or other org. NH_4 salt, and then, after a lapse of time, washing off the slime produced. (*C. A.*)

Glass

30. Color given to glass by tungsten. KITSUZO FUWA. *J. Jap. Cer. Assoc.*, **370,** 302–9(1923).—Coloring action of sodium para-tungstate ($Na_{10}W_{12}O_{41}.28H_2O$), tungsten trioxide and metallic tungsten on glasses with formulas of $R_2O.RO.3SiO_2$ and $R_2O.RO.0.5B_2O_3.3SiO_2$, also effect of oxidizing agent and arsenious acid on the action of the sodium tungstate have been studied. Results of 142 meltings and effect of reheating these glasses are described. *Results.* (1) Sodium tungstate or tungsten trioxide mixed in glass-batches produces no particular color. (2) Metallic tungsten produces very often a yellow or an orange in glass. Similar coloration is rarely observed when sodium tungstate or tungsten trioxide is used. Metallic tungsten gives often a gray to glass. Melting of a batch with metallic tungsten will result in the production of a system as $xW + yWO_3 + zNa_2(K_2)WO_3$ + glass. Presence of the yellow oxide will color the glass yellowish. Suspension of tungsten or its blue oxide will give a gray to the glass. (3) Sodium tungstate has a tendency of producing alabaster effect or opacity, especially in glasses free from boric acid. The tendency is also observable in metallic tungsten and its oxides, though it is very weak. The phenomenon is probably due to fine suspension of tungsten oxides. (4) Sometimes, an excess of tungsten salts, its oxides or metallic tungsten produces gall on surface of glass or massive ppt. at the bottom. They consist of sol. tungstates of alkali metals. (5) Introduction of sodium tungstate accompanied by an oxidizing agent or arsenious acid produces no

particular color. (6) Salts or oxides of tungsten can be used as opacifiers but not as colorants. S. K.

31. Manganese compounds as glass colorants. KITSUZO FUWA. *J. Jap. Cer. Assoc.*, **366,** 80–97(1923).—Coloring action of manganese compds. on various glasses have been studied. Formula of basal glass was $R_2O.RO.3SiO_2$, $R_2O.RO.0.5B_2O_3.3SiO_2$ or $1.3R_2O.RO.6SiO_2$ in which R_2 and R represent Na or K and Ca, Mg, Zn, Ba or Pb respectively. Results of 591 meltings with 100–150 g. or 1 kg. batch are described. 1. *Manganese dioxide.* According to MEYER and ROETGERS, this oxide is dissociated into Mn_2O_3 at 530°C in air. Generally speaking, soda-glass has pink shades and is not so clear as potash-glass, although these differences disappear at higher intensities. PbO encourages the coloring. It is very likely that MnO_2 is decomposed to $xMn_2O_3 + yMnO + zMnO_2$ in the melting. The propn. of these 3 oxides and also the color are affected by the constituents of glass. 2. *Manganous oxide.* Almost colorless, yellow or blue glass is obtained when such amt. of MnO which will produce light purple or pink with MnO_2 are used. 3. *Manganous carbonate.* Its action is similar with that of MnO. Thus the pink or purple does not owe to MnO, but to higher oxides, probably Mn_2O_3. 4. *Manganese dioxide and nitrate of potash or soda.* These nitrates favor the coloring in most cases. 5. *Manganese dioxide and potassium tartrate.* The reducing agent counteracts to the dioxide in most glasses. 6. *Manganese dioxide and arsenious acid.* Arsenious acid acts generally to reduce the coloration of MnO_2 markedly. 7. *Manganese dioxide, arsenious acid and nitrate of potash or soda.* The colors seem to be affected by complex reactions which occur in melting. MnO_2 remaining in the resulting glass will produce a brown and Mn_2O_3 will color it pinkish purple or purple, while MnO has no coloring action. S. K.

32. Coloring action of molybdenum on glass. KITSUZO FUWA. *J. Jap. Cer. Assoc.*, **367,** 129–31(1923).—Action of molybdenum as glass colorant was studied by adding 1.0–7.5% of ammonium molybdate to 20 different glasses with formulas of $R_2O.RO.3SiO_2$ and $R_2O.RO.0.5B_2O_3.3SiO_2$. *Results.* (1) Molybdenum causes no particular coloration; (2) glass with molybdenum has very often been opacified by reheating. This property is closely related with its compn.; (3) the molybdate in excess of about 5% is sepd. as white gall on its surface or as grains at its bottom; they are chiefly composed of alkali molybdates. S. K.

33. Color imparted to glass by chromium. KITSUZO FUWA. *J. Jap. Cer. Assoc.*, **368,** 192–6(1923).—Coloring action of chromium on glasses with formula of $R_2O.RO.3SiO_2$, $R_2O.RO.0.5B_2O_3.3SiO_2$, $1.3R_2O.RO.6SiO_2$ or $R_2O.B_2O_3.6SiO_2$ is reported. Chromium has been introduced in the forms of Cr_2O_3, $K_2Cr_2O_7$ and K_2CrO_4. Influence of potassium nitrate and potassium tartrate on color given by Cr_2O_3 has been studied. *Conclusions.* (1) Generally speaking, chromium compds. impart yellowish green colors to glasses. Compn. of glass affects its shade in yellow; *i. e.*, 0.05% of Cr_2O_3 introduced in batches as such give a green to $Na_2O.CaO.0.5B_2O_3.3SiO_2$, while $Na_2O.CaO.3SiO_2$ is colored light yellowish green. (2) Colors given by $K_2Cr_2O_7$ are richer in yellow than those given by Cr_2O_3, K_2CrO_4 being intermediate in this respect. (3) Addn. of oxidizing agent to a batch contg. Cr_2O_3 encourages the yellow tint, while reducing agent acts to reduce it. It may owe to green coloration by Cr_2O_3 and a yellow one by CrO_3, or it may be ascribed to the action of these agents on iron oxides. S. K.

34. Color given to glass by vanadium. KITSUZO FUWA. *J. Jap. Cer. Assoc.*, **369,** 236–40(1923).—The influence of compn. of glass on its color given by vanadium oxide, V_2O_5, which was added to batch with or without oxidizing agent (potassium nitrate), reducing agent (potassium tartrate) or arsenious oxide, has been detd. The basal glass was $R_2O.RO.3SiO_2$ or $R_2O.RO.0.5B_2O_3.3SiO_2$. The results can be summarized as follows: (1) Generally speaking, color given to glass by vanadium oxide resembles

that imparted by Cr_2O_3, though the latter has stronger tint in yellow than the former. (2) The color is not influenced by compn. of glass. In general, boric acid encourages the coloration. (3) Oxidizing agent added to batch causes a slight increase in yellow, while reducing agent and arsenious acid tend to act the other way. Color of vanadium glass may chiefly owe to V_2O_3 and this may be partly oxidized to V_2O_5 which may be a yellow colorant of glass. (4) V_2O_5 can be used for Cr_2O_3, though it is too expensive for usual purpose. S. K.

35. Color given to glass by antimony oxide. KITSUZO FUWA. *J. Jap. Cer. Assoc.*, **369,** 241–2(1923).—Coloring action of antimony oxide on glass was studied by introducing 10–30% of Sb_4O_6 to glasses with compn. of $1.3R_2O.RO.6SiO_2$ and $R_2O.B_2O_3.6SiO_2$ with the result that the oxide does not cause any particular coloration, and also that reheating of glasses, which have high contents of antimony oxide, in a gas-fired kiln usually produces iridescent effect, light grayish black to black in color, on their surface. S. K.

36. On the thermal expansion of soda-lead glass. JIRO MORI. *J. Jap. Cer. Assoc.*, **368,** 176–80(1923).—Linear expansion of soda-lead glass, completely free from stress, has been detd. at 30° and 100°C. The max. difference between the observed linear expansion and that calcd. by the aid of SCHOTT's coeff. amts. to 12%, while they agree very well only in glasses whose formulas are close to $6SiO_2.1.0PbO.1.0Na_2O$. The author has obtained the following coeff. for linear expansion for lead oxide and soda, taking 0.05, 1.53, 1.53 and 0.45 as those of silica, lime, alumina and magnesia resp.: PbO 0.938 and Na_2O 4.70. The next tables show chem. compns. and coeffs. of linear expansion of glasses used in the expts.

TABLE I.—ANALYSES OF THE GLASSES

No.	PbO	Na_2O	Al_2O_3	CaO	MgO	SiO_2
10	44.73	4.61	0.72	0.07	0.05	49.82
8	41.83	5.61	1.23	trace	.09	51.21
6	39.24	6.90	1.14	0.10	trace	52.61
4	37.45	7.88	0.96	.10	0.03	53.58
2	36.60	8.27	.97	.06	trace	54.10
0	33.96	10.02	1.09	.08	0.01	54.84
1	31.57	11.35	1.15	.04	.02	55.87
3	28.01	12.40	0.98	.09	trace	58.52
5	24.33	13.83	1.19	.33	0.02	60.30
7	22.94	14.06	1.15	.18	trace	61.67
9	16.35	16.34	1.15	.14	0.07	65.95

TABLE II.—FORMULAS AND LINEAR COEFFICIENTS OF EXPANSION

No.	Formula	Observed coeff. $666(\times 10^{-8})$	Calcd. coeff. $678(\times 10^{-8})$	Diff. $+8(\times 10^{-8})$
10	$6SiO_2.1.5PbO.0.5Na_2O$			
8	$6SiO_2.1.4PbO.0.6Na_2O$	705	704	— 1
6	$6SiO_2.1.3PbO.0.7Na_2O$	729	739	+10
4	$6SiO_2.1.2PbO.0.8Na_2O$	761	764	+ 3
2	$6SiO_2.1.1PbO.0.9Na_2O$	781	776	— 5
0	$6SiO_2.1.0PbO.1.0Na_2O$	844	836	— 8
1	$6SiO_2.0.9PbO.1.1Na_2O$	880	877	— 3
3	$6SiO_2.0.8PbO.1.2Na_2O$	903	892	—11
5	$6SiO_2.0.7PbO.1.3Na_2O$	934	933	— 1
7	$6SiO_2.0.6PbO.1.4Na_2O$	929	929	0
9	$6SiO_2.0.5PbO.1.5Na_2O$	966	975	+ 9

The coeff. is on the whole a function of chem. compn. However, as indicated in the latter table, it does not follow the additive law exactly. This fact causes diffs. which are a little larger than exptl. errors. S. K.

37. Cracking and corrosion of glass pots. SANGORO TAKAHASHI. *J. Jap. Cer. Assoc.*, **367**, 149–53(1923).—Descriptions or discussions on life of pots due to cracking, manner, cause and prevention of cracking, life due to corrosion, its manner, cause and prevention are given with photographs. According to statistics for 3 yrs. at the Tokio Elec. Co., most of cracks in covered pots have grown vertically at their inside. This kind of cracking is probably caused by the side pressure of molten glass which favors the growing of vertical minute cracks produced together with those of other directions during the period of filling. Sometimes they are cracked in various directions inside or outside of pot, usually during the period of tempering the pots in pot-arch or before filling batch in the placed pots. Pots should be tempered at least to 1300°C. Corrosion by usual batch contg. 50% of raw materials was far more severe than that by simple cullet batch, indicating that pots are chiefly corroded by fluxes in raw materials before complete melting which takes about 10 hrs. Iron contd. in batch and pot is detrimental in regard to corrosion, especially for lead glass, because it produces metallic lead and ferrous silicates. Excess of flux in raw materials or use of arsenious acid causes sometimes honey-combed corrosion. As conclusion, the author recommends the use of porous pots lined with such a material which will produce sillimanite on using. S. K.

38. On the test of chemical glasses. TORAO KATO. *J. Jap. Cer. Assoc.*, **367**, 138–49(1923).—Detailed descriptions are given on the existing specif. for glass vessels for use in chem. lab. Then the results of an elaborate expt. with beakers and various flasks made by several Jap. manuf. are described. As conclusions, he proposes the adoption of the foll. methods in the testing of chem. glasses. Preliminary treatment: Wash the sample with distilled water after rinsing it well with a soln. of potassium bichromate in concd. sulphuric acid. 1. *Tests for endurance of sudden heating.* (1) Heat the vessel at least to 120°C in an air bath and then immerse it neck foremost in water of 15°. (2) Boil the vessel contg. conc. soln. of calcium chloride whose sp. gr. is 1.33 at 15° for 5 min. on an asbestos plate and immerse it in water of 0°. (3) Put the vessel which has been $^3/_4$ filled with paraffin on an asbestos plate heated by a bunsen burner, take off the heat source, read the temp. and dip it in water of 15° for a moment. The process should be repeated every 5° till it is cracked. Mean value of about 3 samples must be reptd. for temp. over about 160°. 2. *Tests for resistance to water and reagents.* (1) *Water.* Boil distilled water in the vessel which is kept three-quarters full with it for 6 hrs. Loss in wt. should be expressed in mg. per 100 sq. cm. (2) *Acid.* The vessel three-quarters filled with 12% HCl is kept boiling for 3 hrs. The loss is expressed as described above. Its appearance must be inspected. (3) *Alkali.* Same to (2), except that 2% soln. of NaOH is used as reagent. 3. *Test for dissolved alkali.* The water obtained in the test B (1) is tested by rosolic acid for the presence of alkaline reaction. *Standards.* 1. *Endurance of sudden heating.* (1) The neck must remain uncracked. (2) The sample should stand the test. (3) The breaking temp. must be over 140° in beakers and conical flasks and over 130° in round flasks. 2. *Resistance to water and reagents.* (1) *Water.* The max. allowable loss is 5 mg. (2) *Acid.* The max. allowable loss is 5 mg. The testing must cause no change in the appearance. (3) *Alkali.* The max. allowable loss is 30 mg. The boiling must cause no change in the appearance. 3. *Dissolved alkali.* No alkali must be detected. S. K.

39. The staining and etching of glass. L. SPRINGER. *Glasshütte*, **52**, 289; **53**, 277(1922–3). See *Ceram. Abs.*, **2** [2], 23(1923). J. B. P. (*C. A.*)

(1923).—The mixing, shaping, firing and polishing are described. J. B. P. (*C. A.*)

40. Flattening stones. C. J. STAHL. *Glashütte*, **53**, 307, 323–5, 339–41, 355–6

41. The electrodeposition of silver and copper on glass. C. H. PROCTOR. *Glass Ind.*, **4**, 61–3(1923). J. B. P. (*C. A.*)

42. Graphic check on glass-works operation. WALTER J. KNOTHE. *Glass Ind.*, **4**, 83–5(1923). J. B. P. (*C. A.*)

43. Avoiding errors in the analysis of glass sand. J. B. KRAK. *Glass Ind.*, **4**, 103–4(1923). J. B. P. (*C. A.*)

44. The basic glasses industry. A. BIGOT. *Chimie et industrie*, **9**, 851–62(1923).—A review of the prepn., properties and uses of artificial basic silicates, describing more particularly B.'s methods and equipment and the properties of his products. A. P.-C. (*C. A.*)

45. An electric furnace for the melting of quartz goods. W. SCHUEN. *Keram. Rundschau*, **31**, 12(1923); *J. Soc. Glass Tech.*, **7**, 47; cf. *C. A.*, **17**, 2176.—Quartz was melted to a cylindrical mass round an electrically heated carbon tube. At the stage of development attained, only pieces of quartz so shaped could be worked and then by processes adapted from the glass industry. The elec. resistance consisted of a tube of 1 m. length, 35 mm. external diam., and 25 mm. internal diam., made of the purest electrode C. At each end of the tube an electrode consisting of a thick block of C was adjusted to make good elec. contact with it. The electrodes were surrounded by strong Fe bands, and the cables were joined to the electrodes by detachable strong Fe connecting pieces. The resistor and electrodes were built into a furnace capable of rotation. The furnace consisted of a strong Fe cylinder lined with a glazed fire-clay cylinder. Asbestos was placed between the Fe shell and the electrodes to prevent short-circuiting. Only a. c. could be used. The voltage was 40 and the current 800 to 1000 amp. In 20 minutes 18 to 23 kg. of sand could be melted with a current consumption of 7.5 to 8 kw./hr. Sketches of the furnace are given. A piece of waste quartz tube was slipped over the carbon resistor. Sand was then filled in to such a height that the top electrode could not rest on the edge of the furnace but rested on top of the sand. The silica and the carbon reacted, with the formation of Si carbide and CO_2. Any gas developed could escape only with difficulty and so a protective layer was formed between the glowing resistor and the soft quartz. To counteract the high gaseous pressure, a hand-operated lever was used to maintain elec. contact between the resistor and the electrodes. The melting process was concluded in 20 to 30 minutes and then the quartz had to be worked quickly. H. G. (*C. A.*)

46. Gas-producer heat balances. W. B. CHAPMAN. *Glass Worker*, **42** [39], 11, 18, 20(1923); *Glass Ind.*, **4**, 123–6(1923).—A pyrometer recording the sensible heat of the producer gas is recommended as an aid to correct producer operation. A heat balance is offered as a tentative standard compiled from tests of 12 different installations of mech. producers of 4 different makers. J. B. P. (*C. A.*)

47. The action of water and steam under pressure on some soda-lime-silicate glasses. P. W. HODKIN AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **6**, 291–308 (1922).—Four soda-lime-silicate glasses having the approx. compns. $6SiO_2.0.3CaO.1.7Na_2O$, $6SiO_2.0.7CaO.1.3Na_2O$, $6SiO_2.0.8CaO.1.2Na_2O$, and $6SiO_2.CaO.Na_2O$ were subjected to the action of water and steam at pressures varying from 2 to 25 atms. above normal. The action of steam on these glasses is considerable, being greater than that of water at the higher pressures in the case of the glass having the lowest lime content. Corrosion diminishes as the amt. of lime is increased and the amt. of Na_2O decreased. The glass with the highest lime content was unattacked by steam or water in 3 hrs. at 2 to 4 atms. The incrustation formed as a result of corrosion was harder the greater the lime content; a gelatinous layer was formed beneath the incrustation on the glass contg. only 0.3 CaO at 15 atm. pressure. Since the loss in weight recorded was less

than the total alkali found in the water, it is clear that the glass absorbs a considerable quantity of water. The character of the corrosion, which clearly brings out pouring and molding lines, is influenced markedly by the condition of the surface. The autoclave test is considered too severe for soda-lime-silicate glasses which are only required to resist the action of boiling water. Cf. *Ceram. Abs.*, **1** [12], 329(1923).

J. C. S. (*C. A.*)

48. The diphasic nature of glass, as shown by photo-elastic observations. L. N. G. FILON AND F. C. HARRIS. *Proc. Roy. Soc.* (London), **103A,** 561–71(1923); 3 figs., tables.—A specimen of flint glass was heated slowly to 400° and then subjected to a longitudinal pressure of 130.6 bars. The full load was left on for 42 hrs. and then the specimen was allowed to cool slowly under this pressure; the process took 7 hrs. The load was removed and the specimen examd. in Na light between cross Nicols with the aid of a Babinet compensator. The black band indicated a stress difference which was quite considerable and remained of the same sign throughout a cross-section of the specimen. This band extended up to the edge, excluding a possible "skin effect" as the source of a balancing stress. The conclusion, after a mathematical analysis of the results, is "that a portion of the stress is not optically shown. It necessarily follows that the material cannot be homogeneous, but must consist of at least 2 components or 'phases.'" "Further these phases must have different stress-optical coefficients." The stress-optical coeff. for the heavy flint glass in question only changed from 2.31 brewsters to 2.24 brewsters during the above treatment. "It would thus appear that the heat treatment has produced practically no change in the concn. of the disperse phase, so that the phases have not sepd. out, but have been present in the glass from the beginning." An extra-dense flint examd. in the same manner gave positive values for the longitudinal stress, whereas these values were negative in the case of the heavy flint glass. From the above fact, the conclusion is that the "crypto-stress" is an effective pressure in the case of the extra-dense flint. It is suggested that according to Wieners' hypothesis if the particles of the disperse phase are small compared with the wave-length of light, the double refraction due to stress would be largely influenced by change of shape and orientation of the dispersed particles. Further expts. are in progress.

G. E. B. (*C. A.*)

49. The action of potassium carbonate on lead glass. H. D. RICHMOND. *Analyst,* **48,** 260–2(1923).—A sample of K_2CO_3 taken under the Sale of Food and Drugs Acts showed 10 parts of As and 80 parts of sol. Pb per million. Scrapings from the walls of the same bottle gave 12 pts. As and 500 pts. Pb per million. The bottles contained 0.34% of As_2O_3 and 13.1% PbO. It was proved by expt. that K_2CO_3 contg. 16.6% of moisture gave no increase of lead content in six weeks when kept in a "well closed lead-glass bottle." A sample of K_2CO_3 originally carrying less than 5 pts. per million of lead stored for 9 weeks in a lead-glass bottle with "very imperfect" closure contained 20.5% moisture and 150 pts. per million of lead at the end of the time. The result is attributed to the formation of a liquid phase on the surface of the crystals which acts on the bottles. It is recommended that K_2CO_3 be not stored in lead-glass bottles.

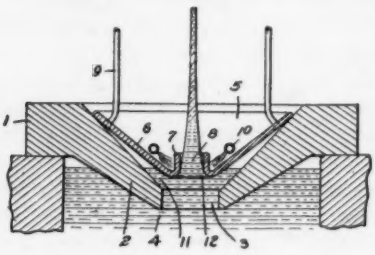
G. E. B. (*C. A.*)

50. Chemical glass and hard glass. AD. LECRENIER. *Bull. federation ind. chim. Belgique,* **1922,** 225–34; *Chem. Zentr.*, **1922,** IV, 30.—Besides numerous data on the glass works of the Val St. Lambert, the formation and properties of hard glass are explained, with emphasis on the importance of careful cooling to obtain the lowest possible coeff. of expansion. On cooling the rate of decrease of strain is proportional to the square of the strain. This relation is derived mathematically. From measurements of many types of glass the coeffs. of expansion for the following substances were calcd.: SiO_2 0.8, B_2O_3 0.1, PbO 3.0, MgO 0.1, Na_2O 10.0, K_2O 8.5, CaO 5. C. C. D. (*C. A.*)

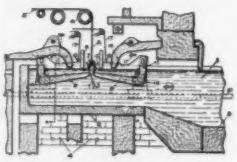
PATENTS

51. Thermo-resistant glass. C. J. VAN NIEUWENBURG. (Holland.) Brit. 200,020, 1922. In the manuf. of thermo-resistant glass, lithium-alumino-silicate, preferably as lepidolite, is added to the ordinary materials, with the addition of a subs. such as zinc oxide or boric acid compd. which promotes the melting process. The glass produced has an increased tensile strength with a resultant increased coeff. of thermal endurance. (*Chem. Trade Jour. & Chem. Eng.*) O. P. R. O.

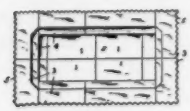
52. Drawing glass sheets. HALBERT K. HITCHCOCK. U. S. 1,463,582, July 31. The process of drawing a glass sheet which consists in chilling a body of glass between the laterally extending walls of a pair of slot members, lying one above the other, in a melted bath of glass, anchoring the base of the glass sheet to said chilled body of glass, and drawing the sheet through the slot of the upper slot member, such upper slot member being of metal and acting as a die, and the lower slot member being of clay.



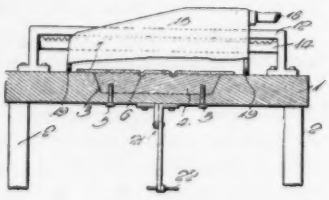
53. Drawing continuous sheet glass. LEONARD D. SOUBIER. U. S. 1,463,273, July 31. In a sheet glass drawing apparatus, a tank containing molten glass, means for drawing a sheet of glass therefrom, a container within the molten glass for segregating that portion of the glass from which the sheet is drawn, the container being divided, substantially in the plane of the glass sheet, into two similar sections, and means for bodily moving the sections toward and from one another to vary the width of the passage therebetween.



54. Glass-handling apparatus. FRANK O'NEILL. U. S. 1,462,652, July 24. A glassware manufacturing apparatus comprising traveling sectional molds, driving means to bring a pair of molds into opposing relation open toward each other, and means carried with one of the molds providing a guide toward the other mold, one of said open molds having a pair of ware engaging shiftable members mounted on the guide, means for engaging an article in one mold, shifting said article out of said mold by travel of the members along the guide means and member coacting means releasing the article into the other mold by opening of the members. Glassware apparatus comprising a traveling carrier, a mold, a rotatable mounting for the mold as to the carrier including a gear, a stationary rack in the line of travel of the gear for rotating the gear, driving means for the carrier providing a station of rest for the mounting, a device movable relatively to the stationary rack and including a toothed section operable to disengage the gear at said station of rest and slow up carrier travel of the mounting as leaving the rack and reaching said device.



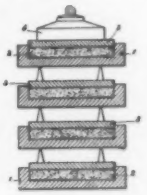
55. Glass-melting tank. HARRY G. WILLETTS. U. S. 1,462,993, July 24. A glass-melting tank having its lateral walls containing refractory bricks, some having one face provided with ribs, the latter being on the outer surface of said tank.



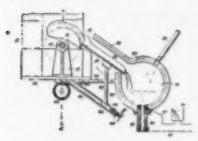
56. Method and machine for constructing embossed glass plate. HARRY F. ANDERSON. U. S. 1,465,507, Aug. 21. The herein described method of forming an embossed sheet of glass consisting in placing a pallet upon a die, forming soft

glass into a thin sheet upon said pallet, drawing said pallet from beneath the sheet of hot glass to allow the sheet of glass to settle upon the die while still hot and in a workable condition, immediately placing a hood over the sheet of glass, and forcing fluid under pressure into said hood to cause the sheet to conform in shape to the die.

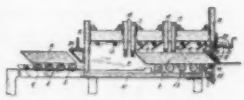
57. Manufacture of articles of glass and the like. MARCEL ARMAND DEMONGEOT. U. S. 1,465,545, Aug. 21. The process of producing a finished molded article from granular or powdered vitrifiable material in a manner to prevent sticking to the mold which consists in placing the material in the mold, raising it while in the mold to a temperature sufficient to soften it but lower than that which would cause sticking to the mold and, while it is being so heated in the mold, subjecting the material to an external pressure acting progressively during the heating operation so as to consolidate the mass in spite of its relatively low temperature.



58. Gathering and delivering apparatus for molten glass. ALLEN CHARLES WILCOX. U. S. 1,465,886, Aug. 21. In apparatus for gathering and delivering molten glass, a main tank, an auxiliary tank, a rotatable gathering disk having a portion extending into said main tank below the normal level of the molten glass, means for rotating the disk, an inclined trough having its lower end positioned to deliver to the auxiliary tank and its upper end positioned to effect removal of the glass gathered on the disk into the trough for conveyance to the auxiliary tank, means for heating the interior of the auxiliary tank, an extension on the auxiliary tank above and parallel to the trough whereby the hot gas from the auxiliary tank will pass over and heat the glass being conveyed by the trough, and means for delivering glass from the auxiliary tank to a glass working apparatus.

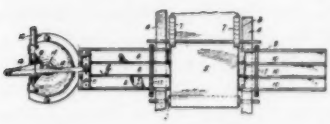


59. Process of and apparatus for forming glass. ROBERT M. CORL. U. S. 1,465,347, Aug. 21. The process of manufacturing sheet glass comprising applying a melting heat to a localized portion of a set mass of glass to flow therefrom a sheet of lesser thickness than the mass, advancing the mass to compensate for the flow of glass therefrom and to maintain a substantially fixed relation between the source of heat and the surface of the mass to which the heat is applied, and successively removing predetermined quantities of glass from a supply of molten glass, permitting them to chill to set condition and successively attaching them to the rear end of the glass mass from which the sheet is flowing and thereby maintaining the continuity of the mass and the flow of the sheet therefrom.



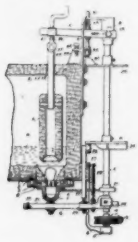
60. Manufacture of heat-insulating articles. JAMES H. DELANY. U. S. 1,464,698, Aug. 14. The improvement in the manufacture of articles having heat-insulating properties due to a vacuum hermetically sealed in glass, which comprises the production, within their interior sealed spaces, of such vacuum as the sole result of the condensation of a gas or vapor confined therein.

61. Sheet-glass-drawing mechanism. THOMAS S. OWENS. U. S. 1,462,495, July 24. In a sheet-glass-drawing mechanism, a chamber through which glass is drawn in sheet form, a table disposed at one side of a soft portion of the sheet and extending transversely thereof and through and beyond each side wall of the chamber, a sheet flattening member guided by the table for movements transversely of the sheet in flattening contact with a surface thereof and being of a length for one end portion to extend without a side of the chamber when another end portion thereof is disposed in rubbing contact with the surface of a

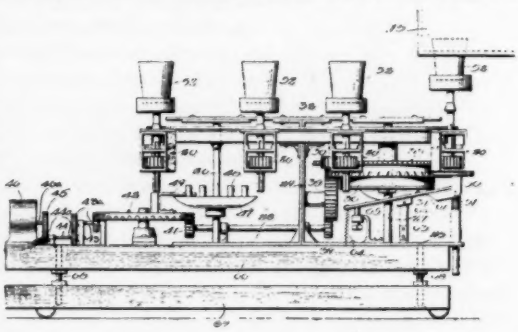


sheet, means without the chamber for imparting reciprocatory movements to the member, and means for cooling each end portion of the flattening member when disposed without a respective side of the chamber.

62. Process and apparatus for feeding glass. WILLIAM J. MILLER. U. S. 1,462,491, July 24. In the feeding of glass, for use in connection with a container for molten glass provided with a discharge orifice, the combination of means intermittently operative for detaching the glass protruding from said orifice to form gathers, a receptacle adapted to contain a quantity of liquid, means for applying said receptacle to the outer end of said orifice between detaching operations whereupon the liquid is gasified by the heat, causing the glass to be temporarily retracted along said orifice for the purposes described, and means for replenishing the supply of liquid to said receptacle when the latter is in its inoperative position, said replenishing means being adjustable to regulate the quantity of liquid supplied to said receptacle. See *Ceram. Abs.*, **2** [8], 177(1923).



63. Glass finishing and polishing machine. GROVER CLEVELAND SCOTT. U. S. 1,462,522, July 24. A machine of the character described including a table, a carrier movable around and upon the table, upright shafts, one of which is rotatable, carrier actuating members on the shafts, a gear wheel loose on the other shaft, means for intermittently rotating the first shaft and thus moving the carrier, means for constantly rotating said gear, a vertically shiftable member adjacent to the gear, a cam rotating with the gear for actuating said shiftable member, a plurality of glass holders each having a stem movable with the carrier above said shifting member, and a gear splined on the stem and engageable with the first named gear, and a frame on the carrier for each holder, in which the holder stem is journaled to rotate and shift vertically, and in which the gear of said stem is freely rotatable and confined against vertical shifting movement with the stem, and a vertically adjustable support for said mechanism consisting of a platform on which the mechanism is mounted, and a base with which the platform is adjustably associated.



64. Glass. SOC. ANON. QUARTZ ET SILICE. Brit. 190,476, Dec. 8, 1922. Fused SiO_2, transparent and free from bubbles, is made by agglomerating the raw material, reduced to fine powder, with gelatinous SiO_2 and then compressing it into molds of the desired shape at a pressure of about 200 kg. per sq. cm. The molded mass is next heated to about 150°, to get rid of moisture, and is then fused in an elec. furnace. Agglomeration of the raw material is facilitated by first transforming it into crystobalite by heating to about 1500°. (*C. A.*)

65. Glass. SOC. ANON. QUARTZ ET SILICE. Brit. 190,477, Dec. 8, 1922. To obtain fused quartz free from bubbles, compact siliceous rocks of a high degree of purity and preferably contg. no micro-cryst. cement are melted. The rock is cut into cylinders which are perforated axially so that they can be threaded on the C electrode of the furnace. (*C. A.*)

66. Glass. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 189,926, Oct. 6, 1921.

Shaped articles, rod, or tube of transparent SiO_2 are made by fusing the SiO_2 under atm. pressure, cooling, reheating the SiO_2 to a plastic state, and then molding to a desired form, or extruding through a die, by applying pressure. The SiO_2 is first freed from bubbles by melting it *in vacuo* and subjecting it to pressure in the manner described in 188,451. A suitable construction is specified. (*C. A.*)

Heavy Clay Products

67. Bricks from oil shale. ANON. *Indus. Aust. & Min. Standard*, **70**, 132(1923).—Experiments are being made in Ger. to produce bricks from oil shale cheaper than clay bricks. One process mixed shale with cement or lime and subjected it to hydraulic pressure, but was not entirely satisfactory. Another process which has been tried successfully at the Prussian Geol. Survey and at several brickworks is as follows: the shales, after the pyrites has been sepd. from them by sifting, are ground up with a propn. of clay or sand which varies according to the richness of the shales, and the powdered mixt. is then molded into bricks, which are put straight into the kiln without being dried. No fuel is required to burn them, as the inherent content of oil in the shales suffices for that purpose. Bricks made in this way are said to be slightly lighter in color than ordinary bricks, but to be no different in appearance otherwise. O. P. R. O.

68. Silica (Sweden). ANON. *Brit. Clayworker*, **32**, 137(1923).—Deep and extensive deposits of silica have recently been discovered in the province of Scania, Sweden; the presence of some 20% of bituminous matter in this silica gives greater value to the discovery, as with such raw material no intermediary processes are necessary, the material as it is brought up being simply pressed into wall, floor and roof tiles of a very high standard of quality. Silica of this kind is to be found nowhere else in the world, the discovery is consequently unique as well as extremely valuable. The total yield is estd. at 800,000 cu. m., the whole being easily accessible at a depth of 5 m.; sufficient to keep all the Scand. countries in building tiles for generations, and leave a margin for export. A new method for the production of tiles in large quantities by special machinery has now been patented, whereby the tiles are at the same time impregnated against damp. These patents, together with the silica deposits, have been taken over by a Swedish building material concern; arrangements have been made to produce 100,000 sq. m. dampproof tiles per yr. O. P. R. O.

69. Firing of building brick in Hoffmann kilns. M. FERNAND WATTEBLED. *Brit. Clayworker*, **32**, 71(1923).—A résumé of a valuable tech. monograph by Wattebled of Paris. The rept. is issued by Société d'Encouragement pour l'Industrie Nationale. According to the raw materials used, the temps. at which the requisite chem. actions are correctly completed may vary from 700 to 1400°C, but max. results are obtained by firing at the highest allowable temp. which will not destroy the color or shape of the goods. The first condition is to ascertain the temp. of gases of combustion and maintain it. This is done by direct measurement and by calcn. The former method requires expensive instruments. By calcn., however, it is possible to det. the temp. of gases at the exact moment of their formation before any loss by cooling occurs. W. describes how he perfected an instrument for taking samples of the gases of combustion simultaneously from a large number of points in a Hoffmann kiln in full fire and was enabled to obtain definite confirmation of a series of calcns. worked out to show the actual reln. between temp. and carbonic acid content. A fuel of known calorific value was used throughout the expts. He illustrates his points by diagrams and tables. They show that to obtain the max. useful effect from the combustion of fuel in a kiln, it is essential that the production of carbonic acid should be constant and correspond with the amt. showing the production of the firing temp. of the goods. There are 4 distinct zones in the process of firing: (1) that which comprises chambers of goods in process of

cooling; (2) that in which combustion of the fuel takes place; (3) that in front where green goods are being heated; (4) that in which goods are being set and drawn. Intermittent firing causes a considerable loss of time and heat and is obviously not the most satisfactory. The phenomena which occur in the firing zone are discussed at length by means of tables and diagrams, the calcns. being based on 9 rows of feed holes. The ideal temp. curve is shown in the diagram and the conclusion is that in order to attain it in the burning of a Hoffmann kiln mech. continuous feeding is essential. A mech. feeding device must satisfy the following conditions: (1) Possibility of varying the speed of the whole installation. (2) Coördination of the working of all the units of fuel distribution. (3) Possibility of varying the rate of feed of each individual unit according to its position on the kiln, while the general movement is coördinated. (4) A type of machine that can deliver to the feed-holes very small but strictly regular quantities of fuel. Instantaneous combustion of the fuel is essential and is insured by fine pulverization, and by the fact that the fuel falls unimpeded through a certain height in the interior of the kiln. The heat value of the flame of a number of different types of fuel is as follows: (Amounts in degrees C.) Oak wood, 1865; peat (dry), 2020; lignite, 1960; long flame coal, 1960; anthracite, 2030; coke dust, 2018; locomotive ashes, 2029; colliery duff, 68% ash, 1635. Inferior fuels can be successfully used if finely pulverized, the author has proved by firing more than 100 T. of bricks at 1000°C every 48 hrs., in a kiln burning only locomotive ashes. The exhaustive researches of W., have laid the foundation of a vaulable tech. advance in the large scale practice of brick firing. O. P. R. O.

70. Specifications for building and sandlime brick in Austria. ANON. *Tonind.-Ztg.*, **47**, 492–3(1923).—*Building brick.* (1) *Definition.* All fired brick made of clay, loam, or clay-like material together with sand, broken quartz rock, dry clay powder, or fired clay are classed as building brick. (2) *Kinds.* Brick are divided into the following classes depending upon their compress. strength: (*a*) clinker (*b*) hardfired brick (*c*) common brick. (3) *Compress. strength.* The av. compress. strength made upon at least 10 specimens should be at least above the foll. values: (*a*) clinker = 600 kg./qcm. (*b*) hardfired brick = 300 kg./qcm. (*c*) common brick = 120 kg./qcm. Brick which do not meet these specif. should be called "underfired." (4) *Shape.* Building brick should have a true shape and should correspond to the following dimensions: Large size brick—29 cm. long, 14 cm. wide, and 6.5 cm. high. Small size brick—25 cm. long, 12 cm. wide, and 6.5 cm. high. (5) *Absorption.* The absorption will be tested as follows: At least 5 bricks should be dried until they no longer lose wt. after which they are weighed. They are then immersed in water and allowed to remain there until they no longer absorb water. The increase in wt. above the dried brick should be less than the following: (*a*) clinker = 2% (*b*) hardfired brick = 8%. The absorption for common brick is not limited but is usually above 8%. (6) *Resist. to freezing.* Clinker, hardfired brick, and brick used as front brick and for facing must be resistant to the freezing test. The freezing test is conducted in the foll. manner: About 10 brick are immersed in water in a hole at least $^1/_2$ cbm. or in a tank of corresponding size, 25 times, being frozen to a temp. of at least 4°C each time for at least 4 hrs. and then allowed to heat up to room temp. *Sand lime brick.* (1) *Definition.* All brick made from a mortar-like mixt. of a high quartz and low feldspar sand and lime which has been pressed and treated with steam at a pressure of 8 atms. are known as sand lime brick. (2) *Kinds and compress. strength.* Hard sand lime brick must have an av. compress. strength of at least 120 kg./qcm., this being the av. of at least 10 specimens. Sand lime brick not meeting these specif. are known as medium hard. (3) *Shape.* The shape corresponds to that of clay brick. They should be true and correspond to the following dimensions: Large size brick: 29 cm. long, 14 cm. wide, and 6.5 cm.

high. Small size brick: 25 cm. long, 12 cm. wide, and 6.5 cm. high. (4) *Absorption.* The absorption of water is not limited but as a rule should be between 11 and 17%. (5) *Other requirements.* (*a*) Upon being struck they should have a clear ring. (*b*) The fracture should have a uniform structure and should be free from lime grains and holes; the presence of large pieces of silica are admissible. H. G. S.

71. Manufacture of hand molded sand-faced brick and tile. ANON. *Brit. Clayworker*, **32**, 112–3(1923).—Different methods of setting brick and tile in kilns are described. H. G. S.

72. Modern tile making. ANON. *Brit. Clayworker*, **32**, 100–2(1923).—The raw materials used for making tile are described. Sawdust is used in the manuf. of filter tile and for others which are required to be extremely porous. It is a mistake to use soft wood sawdust for this purpose as the particles are too coarse, sawdust from hard-wood is in every way preferable, as well as producing much finer pores. H. G. S.

73. Microscopic structure of common brick. SEIJI KONDO. *J. Jap. Cer. Assoc.*, **370**, 283–91(1923).—Structure of common brick manufd. at the 2 biggest plants in Tokio and Osaka districts is reptd. Their chief raw materials are loams in Tokio and stoneware-clays in Osaka, small propns. of sand being used at both plants. Their mineral compns. are given. The brick are made with spiral presses and burned in ring kilns. They are classified into 8 grades in Tokio and 6 in Osaka. Quality of the brick is as follows:

	Tokio		Osaka	
	Grade 1	Grade 8	Grade 1	Grade 6
Absorption in 48 hrs.	9.94%	18.17%	6.66%	14.60%
Porosity	27.04%	36.87%	22.93%	32.29%
Crushing strength (kg. per sq. cm.)	554	139	595	162

1. *Structure of the Tokio brick.* Thin sections of brick, which were fired at cone 09a–05a in a ring kiln in Tokio, show plagioclase, quartz, impure dehydrated clay, hypersthene, orthoclase and very small amts. of microcline, hornblende and fragments of groundmass. Hypersthene has slight sign of fusion even in the grade 8. Plagioclase in the grades 1–5 and orthoclase in grade 1 show similar signs. The grades 1–5 have slight amts. of glass. 2. *Structure of the Osaka brick.* Thin sections of brick, which were fired at cone 05a–03a in a ring kiln in Osaka, contain quartz, impure dehydrated clay, orthoclase, radiolaria quartzite, plagioclase and slight amts. of microcline, hypersthene, hornblende and biotite. Plagioclase in all grades, hornblende in the grades 1–5 and quartz, orthoclase as well as microcline in the grades 1–4 are melted in varying degrees. Even the grade 6 contains a small quantity of glass. The grades 1–4 have considerable amts. of sillimanite. 3. *Min. compn.* Approx. min. compns. of the brick have been calcd. from their analyses under assumptions that the brick have only 7 constituents as described below and also that hypersthene has a definite compn. as $3MgO.2FeO.5SiO_2$.

Brick	Orthoclase and microcline	Albite	Anorthite	Hyperthene	Dehydrated clay	Quartz	Ferric oxide
Tokio	10.5	15.0	15.8	13.0	17.0	23.6	5.1
Osaka	13.0	6.6	2.4	3.6	18.7	52.1	3.6

4. *Formation of glass.* Of the Tokio brick, the grades 1–3 contain small amts. of colorless and light brown glasses, while the grades 4 and 5 have only light brown glass. Of the Osaka brick, the grades 1–3 have considerable amts. of light brown glass with many cracks and bubbles and also cracked colorless glass which appears to be filling most of voids in the thin sections, diam. of these glasses being often as large as 1.1–

1.5 mm.; the grade 6 has only a small amt. of light brown glass. The facts that quartz, feldspars and the other minerals were melted at such low temps. and also that considerable amts. of glass were formed may probably owe to the presence of minute particles of various minerals and their products of decompn., which would compose very fusible mixts. non-uniformly distributed all through the body. These eutectic mixts. will melt at first in the firing and the glass will act on grains of quartz and the other minerals to dissolve them. Large colorless glasses in thin sections of the Osaka brick have often regular outlines or small nuclei of quartz or feldspars. 5. *Formation of sillimanite.* The grades 1–4 of the Osaka brick have considerable amounts of sillimanite. Many crystals in the grade 1–4 are as long as 0.05–0.02 mm. Twelve micro-photographs are given. S. K.

74. The heat-insulating power of structural material. H. BURCHARTZ. *Tonind.-Ztg.*, **46,** 713–4, 721–2; *Chem. Zentr.*, **1922,** IV, 701.—Expts. were made on sand-lime brick with the heat-insulation tester of Gary-Dittmer. Its high heat-insulation capacity is due to its porosity and quartz content. Sand-lime brick can be ranked with other brick in regard to this property. C. C. D. (*C. A.*)

PATENT

75. Channel brick. ARTHUR HARDONCOURT. U. S. 1,463,697, July 31. A channel brick having two substantially parallel channels which are relatively deep and leave only webs between the bottom of the channels and the bottom of the channel-brick, corrugations on the channel brick at the inner sides of the channels, the channel brick at the outer sides of the channel being curved downwardly and inwardly to the inner sides of the channels so that the channel brick at the channels will be strong and the channels at their upper portions will be relatively narrow while sufficient to permit a mason to introduce his fingers while partially closed into one of the channels without striking his knuckles against the outer walls of the channels, the channel brick having load-bearing portions between and at the outer sides of the channels.

Refractories

76. The Derbyshire Silica Firebrick Co. works at Frieden. ANON. *Brit. Clayworker*, **32,** 113–4(1923). H. G. S.

77. Setting a Lancashire boiler. ANON. *Brit. Clayworker*, **32,** 119(1923).—Special blocks for setting boilers are described. H. G. S.

78. On refractory cement. TEI TAKAMATSU AND MASATAKE KUWAYAMA. *J. Jap. Cer. Assoc.*, **368,** 167–75(1923).—The authors have worked for the production of substitutes for "hytempite" which is imported from America. Hytempite has alk. reaction, its strength corresponding to 0.0276 g. NaOH per g. of sample. Analysis of dried sample is: Total silica 68.66, sol. silica 4.33, alumina 16.26, ferric oxide 2.60, lime 1.25, magnesia 0.92, soda 3.73, and loss on ignition 6.53%. It melts at about cone 15, while its insol. portion has a refractoriness of cone 27. The effect of adding different amts. of water glass to the insol. portion of hytempite, 7 kinds of domestic clays and a diatomaceous earth on their refractoriness are shown; the results indicate a close similarity between Mizuno clay and the insol. portion of hytempite. The expts. of mfg. refractory cement with Mizuno clay, grog and water glass are reptd. Analyses of these materials are:

	SiO_2	Al_2O_3	Fe_2O_3	CaO	Mg	Na	Ignition loss
Mizuno clay	69.12	16.68	0.55	1.80	0.99	...	8.20
Grog	73.20	21.84	.90	1.24	.83	...	...
Water glass	36.56	...	....	....	....	18.81	44.63

Two small slabs cut from fire brick were cemented with each mixt. The blocks were then heated at 1350°C (for 8 hrs.), 1580° (100 hrs.), 1510° (104 hrs.), 1470° (110 hrs.), 1490° (113 hrs.) and 1345° (10 hrs.). Then they were tested as cements for cracked glass pots. The foll. mixts. together with several others are at least as good as hytempite:

No.	Mizuno clay	Water glass	Grog	Water
20	30	15	55	9
42	30	25	45	5
43	25	25	50	5

S. K.

79. Jointing materials for refractories. D. JONES AND W. EMERY. *Foundry Trades Jour.*, **28,** July 12(1923).—The authors devised expts. to test the effect of mixt. in various propns. of fire clay, ganister and crushed silica brick (grog), and in some cases the effect of adding certain compds., *e. g.*, plaster, lime, and sodium silicate to the mixts. The mat. were first thoroughly mixed in the dry state, and water was then added to the proper consistency. A layer about 3 in. thick was spread between two 2-in. cubes prepd. from hand-make silica brick. When air-dried, the samples were fired to cone 16 in an elec. fur. under load of 50 lbs. per sq. in. The temp. was raised for 3 hrs. to cone 16 and then maintained constant for 1 hr. In order to provide a more drastic test, some mixts. were heated to cone 20 under the same load. Briquettes were also made from the mixts. and tested for contraction or expansion, crushing strength and resist. to slag-penetration. It was found that mixts. of fire clay and ganister have much greater expansion than those of clay and grog, but on the average these mixts. have a greater crushing strength and much higher resist. to slag-penetration. Although jointings of clay-ganister mixt. lack adhesive power, they are very hard and firm compared with clay-grog mixts., which are deficient in mech. strength and are crushed out when fired under load. Clay-grog mixts. especially such as have the latter component in excess, are badly attacked by slag. These briquettes have open texture with large pores into which the slag freely penetrates. Clay-ganister mixts. sinter more readily than clay-grog mixts., and a clay-ganister mixt. of 1:1 softens so much that, heated to cone 16 under load, the cement is squeezed out. It was found that an admixt. of fire clay, ganister and grog gave the best results. In 2 mixts. a fat, plastic ball clay was added in slip form instead of ordinary fire clay, and one was found to be exceptionally good in all respects. Compared with a mixt. using fire clay, with ganister and grog in the same propns., the mech. strength was more than doubled and resistance to slag-penetration greatly increased. The jointing was very hard and firm, and even when fired to cone 20, the cement was still good. (*Bull. Cleveland Tech. Inst.*, **1923,** July.) O. P. R. O.

80. Refractory silica materials of S. Wales, with special reference to the influence of texture. W. R. R. JONES. *Trans. Ceram. Soc.* (England), **21,** 358–93(1921–2).—Microscopical examn. indicated that quartzites suitable for use in the manuf. of silica bricks should consist of angular grains set in a siliceous cement in optical continuity with the quartz grains, and should contain some chert or crypto-cryst. silica, but little non-siliceous matter. They should show a wave-like extinction of the quartz grains. The crushed silica rocks and sands were graded by sieving and by the elutriation of the material passing through a 30-mesh sieve. The results obtained gave further evidence of the similarity of the materials used in S. Wales for the manuf. of silica brick. Test-pieces molded with water from the raw materials and without the addn. of any bonding material were heated to 1350° and their cold crushing strengths subsequently detd. It was seen that the finer the grade of the material the higher was the compressive strength of the test-pieces. The drying shrinkage was small, while a further shrinkage of about 0.2% was found after firing to 1000°, but the brick began

to show expansions after burning at 100°. The sp. gr. of the brick decreased with successive firings, the rate of conversion of the quartz increasing with the fineness of the material. J. S. C. I.

81. Requirements of a refractory mortar. R. F. LINDSAY. *Chem. Met. Eng.*, **28,** 1080(1923).—A refractory mortar must have a m. p. close to that of the brick with which it is used. The expansion and contraction of the mortar and also its chem. properties should be similar to those of the brick. W. H. B. (*C. A.*)

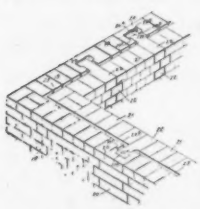
82. The melting point of coal ash. F. S. SINNATT, A. B. OWLES AND N. SIMPKIN. *Colliery Guardian*, **125,** 1131(1923).—A new method for detg. the m. p. of coal ash, used successfully for 4 yrs., is described. A small compact furnace of MgO brick is bored through the center to take a SiO_2 tube. A vertical hole at right angles serves for heating the SiO_2 tube with an oxy-coal gas burner beneath the brick. Detns. are made with 0.2 g. of ash, prepd. in thread shape. Ash from coal from different horizons in the same seam varied considerably in m. p., showing the need of careful sampling. Certain bands in a seam had a very high m. p. (over 1440°) compared with the bulk of the seam. No relation was found between m. p. and chem. compn.
C. C. D. (*C. A.*)

83. Properties and testing of refractories. R. RIEKE. *Gas u. Wasserfach*, **66,** 33–6, 53–5, 66–8(1923). J. L. W. (*C. A.*)

PATENTS

84. Crucibles, retorts, etc. FEROLITE, LTD. AND H. B. CLAPP. Brit. 189,692, Feb. 7, 1922. Crucibles, retorts, and other vessels for high temp. work are molded from a mixt. of chromite and ferro-Si with a binding agent such as Na silicate soln. Cf. 183,219. (*C. A.*)

85. Treating alunite. E. MOLDENKE. U. S. 1,457,787, June 5. Finely divided alunite is treated with more than sufficient H_2SO_4 to convert the Al into sulfate, forming a paste, the mixt is heated until it forms a brittle cake and after the material is disintegrated it is introduced into a closed chamber and heated to cause evolution of fumes from the free acid present and render the values sol. in H_2O. The heating and hardening of the pasty mixt. may be carried out on a sheet-metal flexible conveyor the flexing of which serves to break the caked material and dislodge it from the conveyor. Clay and bauxite when treated with H_2SO_4 may be similarly handled. (*C. A.*)



86. Furnace wall. MICHAEL LIPTAK. U. S. 1,463,044, July 24. A wall structure made up of a main masonry outer wall and a replaceable inner facing wall, one of said walls including blocks having lock head seats with entrance throats leading thereto, and the other wall including blocks having necks formed with lock heads, said heads being insertable into and removable from interlocking engagement with said seats by movement in the wall in the space between immediately adjacent lower and upper layers of blocks or brick. (Cf. *Ceram. Abs.*, **2** [9], 196(1923).)

87. Furnace wall. MICHAEL LIPTAK. U. S. 1,463,050, July 24. A composite furnace wall comprising a permanent masonry outer wall having therein horizontal rows of sill-forming blocks, overlying horizontal rows of lintels and intervening pilasters, forming vertically spaced rows of horizontally spaced pockets, in combination with a high refractory replaceable masonry inner wall including shelf-forming blocks projected into and anchored within the pockets of said permanent wall.

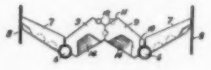
88. Partition wall for furnaces. MICHAEL LIPTAK. U. S. 1,463,051, July 24. A composite partition wall for furnaces comprising a permanent center wall and shelf-forming elements anchored to and projecting from opposite sides of said wall and replaceable facing walls anchored to said center wall by said shelf-forming elements.

89. Furnace wall. MICHAEL LIPTAK. U. S. 1,463,052, July 24. A composite furnace wall comprising a permanent masonry outer wall having therein horizontal rows of sill-forming blocks, overlying horizontal rows of lintels and intervening pilasters, forming vertically spaced rows of horizontally spaced pockets, in combination with a high refractory replaceable masonry inner wall including shelf-forming blocks projected into and anchored within the pockets of said permanent wall, said shelf-forming blocks each being substantially the width of a coöperating pocket.

90. Furnace wall. MICHAEL LIPTAK. U. S. 1,463,053, July 24. A composite furnace wall comprising a permanent masonry outer wall having horizontally spaced pilasters and intervening pockets, in combination with a high refractory inner wall including shelf-forming blocks that project into the pockets of said permanent outer wall, said shelf-forming blocks comprising outside and intermediate sections, the former having interlocking engagement with said pilasters and being held interlocked therewith by the intermediate lock sections.

91. Furnace wall. MICHAEL LIPTAK. U. S. 1,463,058, July 24. A wall structure made up of a masonry outer wall and a replaceable inner wall, said outer wall including tile anchor boxes and said inner wall including shelf-forming blocks extended into and anchored within said anchor boxes, said anchor boxes being rectangular, the bottom portions thereof affording sills and the top portions thereof affording lintels and the end portions thereof affording pilasters in the outer wall, said anchor boxes being horizontally divided and set with their pocket-forming portions aligned but with their pilaster-forming end portions offset so as to form staggered joints between the upper and lower box-forming sections.

92. Fire-brick arch. ALFRED H. WILLETT. U. S. 1,463,184, July 31. A tube supported fire brick arch construction comprising a series of pairs of invertible brick supported between two tubes, said brick in each pair being inclined toward and resting against each other and each brick having at the meeting end two oppositely inclined supporting surfaces constructed to permit the brick to be rested against each other either face upward. See *Ceram. Abs.*, **1** [5], 142(1922); *ibid.*, **1** [7], 185(1922).



93. Arch brick. GUY CARLETON DENNEY. U. S. 1,463,156, July 31. An arch brick member having along one edge an arch brick support engaging surface and having on its opposite edge a cut back portion having an inclined end surface and a projecting portion having an oppositely inclined end surface, the planes of said surfaces not intersecting within the body of the member and said portions being complementary whereby when a pair of such members are assembled in reversed relation they coöperate to form a brick, said inclined end surfaces being serrated or roughened.

Terra Cotta

94. Roofing tile industry in Ishikawa prefecture. KYOTARO KOYAMA, TOMOZO ISHIDA AND YOSHITAKA NAKAMURA. *J. Jap. Cer. Assoc.*, **369**, 243–54(1923).—Only glazed roofing tiles are produced in the prefecture. The body is composed of 1 or 2 kinds of local clays with or without addn. of sandy clay or sand. Eight kinds of clay, each used as sole body mat., have compn.: silica 59.49–67.77, alumina 13.46–20.21, ferric oxide 3.53–7.52, lime 0.51–4.41, magnesia 0.06–2.21, alkalies 0.03–0.82 and loss on ignition 7.60–16.16%. Body is prepd. by kneading its mat. with or without aid of pug mill and clay cutter. No machine is used in the forming. The tiles are glazed after biscuit-firing. Glazes are composed of local rock, ferric oxide and pyrolusite, sometimes with addn. of galena. Now they are fired in semi-continuous kilns called

"Noborigama" at cone 6a–9. All samples taken from 17 manufacturers have perfectly stood the usual test for freezing. Their absorption in 48 hrs. ranged from 3.4 to 17.7%.
S. K.

Whiteware

95. Improvement of the firing procedure for whiteware kilns. E. REUTLINGER. *Ber. der Deut. Keram. Gesell.*, **4** [1], 1–35(1923).—The results of several firings in a small coal fired kiln of 6 cu. m. vol. and in several industrial kilns of 45–170 cu. m. vol., are given in graphs and tables. The object of the expts. was to find the best firing procedure using as little coal as possible. All temp. were measured both with thermocouples and cones. The gases were analyzed both with the Orsat and recording instruments, and a continuous draft record was taken. The ideal curve for the biscuit burn in the small kiln is (1) raise temp. to 100°C the first hr. (2) raise rapidly at 350°C rise per hr. for 2 hrs. to 800°C (3) raise slowly for 7–8 hrs. at 40–60°C rise per hr. to 1150°C. The ideal curve for the glost burn is (1) raise temp. 230°C per hr. for 3 hrs. to 700°C (2) raise at 120°C per hr. for 3 hrs. to 1050°C (3) hold at end temp. for: $^1/_2$–1 hr. The curves for the industrial kilns naturally show a longer burning time. In these kilns a good biscuit burn on small ware will use from 0.25–0.40 lb. of coal per lb. of ware + sagger burned, and for the glost burn, 0.20–0.25 lb. of coal per lb. of ware + sagger. In firing large sanitary ware, 2–3 times this amt. of coal will be used. The larger the vol. of the kiln, the less coal per unit of vol. is used. The importance of kiln design in order to diminish temp. differences and shorten burning time is emphasized, and expts. are now under way along this line. By connecting together several kilns having a single chimney and using the heat from a cooling kiln to warm up a cold kiln, a saving of 15–20% in the amt. of coal used is possible. See *Ceram. Abs.*, **1** [8], 214(1923). E. N. B.

96. Chemical porcelain. G. N. WHITE. *Trans. Ceram. Soc.* (England), **21,** [4], 320–7(1921–2).—The resistance to fracture, in consequence of abrupt changes in temp., of heterogeneous supercooled fluids, of which hard porcelain is a type, is in general raised by conversion as far as possible into the cryst. state. This requires the bulk of the Al_2O_3 in porcelain to have crystd. out as sillimanite. The formation of sillimanite is the more complete the lower the proportion of bases present, although a certain proportion of bases is essential to the formation of sillimanite. The practical problem is therefore to det. the minimum propn. of bases which gives under practicable time-temp. treatment a totally impermeable body. The relative resist. to fracture of porcelain was detd. by heating test-pieces in a bath of molten $NaHSO_4$ at a definite temp. and then transferring rapidly to a bath of eosin soln. J. S. C. I.

97. The production of porcelain for electrical insulation. III. F. H. RIDDLE. *J. Am. Inst. Elec. Eng.*, **42,** 631–5(1923); cf. *Ceram. Abs.*, **2** [9], 199(1923).—China and ball clays are tested for fired color, porosity, fineness of grain, and strength. Particular emphasis is placed upon the grain size of quartz, for which water sepn. is recommended. Limits of compn. are wide but the quality depends on the compn. Special spark-plug porcelains are made by eliminating feldspar and quartz and substituting synthetic calcines. Firing first drives out the H_2O then the feldspar melts and dissolves the clay and quartz or assists these to change into sillimanite and free SiO_2. The soln. of quartz depends upon the grain size and heat treatment Ordinary porcelain has a tensile strength of 3000–6000 lbs. per sq. in. and a coeff. of linear expansion of 4–9 $\times 10^{-6}$ per °, while special porcelain may reach a strength of 12,000 lbs. and a coeff. of 2.7×10^{-6}.
W. E. R. (*C. A.*)

98. Experiments on the low-temperature final firing of porcelain. W. FUNK. *Sprechsaal*, **55,** 312–3; *Chem. Zentr.*, **1922,** IV, 700–1.—The expts. were carried out at cones 8–9 in the compn. range specified by Hertwig-Möhrenbach. In general the stability of the porcelains was not great. C. C. D. (*C. A.*)

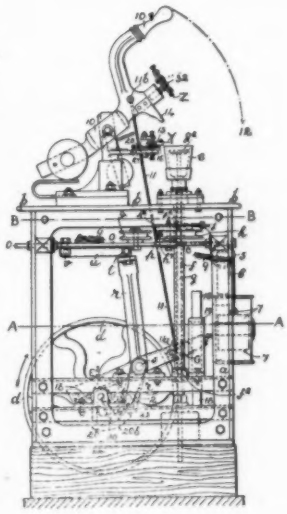
99. Stoneware as material for the construction of apparatus and machines. C. HEINEL. *Chem. App.*, **10,** 85–7, 93–5(1923).—A mathematical consideration, with 7 charts and tables, of some of the properties of stoneware, such as flexibility, compressibility, porosity, heat cond., expansion, resist. to internal and external pressure, etc.
J. H. M. (*C. A.*)

BOOK

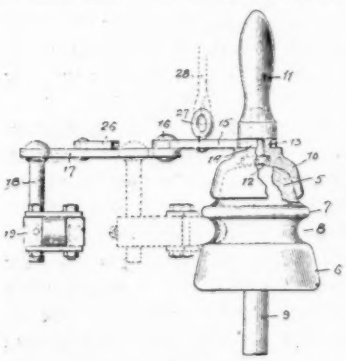
100. The A. B. C. of English Salt-Glaze Stoneware, from Dwight to Doulton. J. F. BLACKER. London: Stanley Paul & Co., 15s. net. Reviewed in *J. Roy. Soc. Arts*, **71,** 565(1923). (*C. A.*)

PATENTS

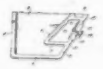
101. Machine for use in the manufacture of teacups, breakfast cups, beakers, and other vessels or articles of pottery. ELIJAH BROOKES. U. S. 1,465,577, Aug. 21. In a pottery machine, a chuck for holding the article provided with a vertical driving shaft, a lever pivoted to rock in a horizontal plane and provided with a knife for cutting off the upper part of the article when revolving with the chuck, an arm pivoted to work in a vertical plane and provided with a projection which operates the said lever when the arm is lowered, and a rounding tool carried by the said arm and engaging with the rim of the article after its upper part has been cut off by the knife.



102. Apparatus for shaping insulators. LORENZO C. BUCKLEY. U. S. 1,465,157, Aug. 14. A shaping tool for pin type insulators, comprising a cap adapted to fit in the head of a preformed insulator blank, and a lateral shaper pivoted with relation to the cap and adapted to bear against the side of the blank during its rotation.



103. Washtub. M. HAGAMAN. U. S. 1,462,573, July 24. A wash tub having bottom, front, back and end walls, and a hollow imperforate box-like projection extending rearwardly from the inner upper portion of the face of the front wall and provided with an inclined rubbing surface on the rear side thereof, said boxlike projection being of less width than the width of the front wall and of less depth than the depth of the tub, whereby said projection is spaced from the opposite ends of the tub and from the bottom of the tub.



Equipment and Apparatus

104. The A. E. G. optical pyrometer. ANON. *Brit. Clayworker*, **32,** 108(1923).—The A. E. G. instrument is a simplified form of the Holborn-Kurlbaum pyrometer. It registers temps. between 650° and 1500°C to within an accuracy of ±5°. It is based upon the principle of the disappearing filament, and is extremely simple in construction.

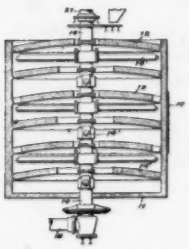
It consists namely of central optical tube, in the forepart of which a carbon filament lamp is fixed. This tube is encased within a second, which carries a double wound, non-inductive resistance coil. A 3rd protective tube, upon which is the temp. scale, covers the resistance tube. In addn. this outer tube is fitted with a slide, which is in contact with the resist. The instrument is provided with a grip, which is held in the left hand, the right being free to manipulate the slide. The pyrometer is graduated in accordance with the voltage of the supply cable; variation in the voltage, therefore, must be allowed for in making exact measurements. The temp. correction for a variation of one volt is given on the slide. For instance, if, in using a 220-volt pyrometer, the correction for which is ±2 per volt, the voltmeter registers 220 volts, the true temp. will be 4 higher than that indicated on the scale. These instruments are made to operate on both a. c. and d. c. circuits up to 220 volts; for an a. c. circuit of over 220 volts, a transformer is necessary. For voltages up to 190, the pyrometer may be coupled up directly with the supply cable. H. G. S.

105. A proposal for the establishment of a new scale of hardness for glass and crystals. BERNHARD HALLE. *Deut. opt. Wochschr.*, **8**, 98–100; *Chem. Zentr.*, **1922**, IV, 101.—After a short summary of older methods and app., a modification of the method of Rosiwal is described. Instead of a definite amt. of abrasive being used until it becomes useless, it is continuously renewed and that used is sepd. out. It is assumed that the hardness is proportional to the loss in wt. under fixed conditions. The abrasive and the necessary liquid (usually H_2O, but olive oil for diamond and EtOH or C_6H_6 for H_2O-sol. crystals) are enclosed in a 2-section shell and the latter is so rotated that the sample is given a cycloidal motion. The used abrasive is scraped from the lower section of the shell; emery or carborundum is used for soft materials, diamond for hard. C. C. D. (*C. A.*)

106. The new precision pycnometer. B. BERGDAHL. *Chem.-Ztg.*, **47**, 530(1923).—The neck of the app. is cut off obliquely. The stopper has a hole bored from the lower end which passes through the side at a point just above the low side of the oblique neck. The stopper is inserted in the filled app., the excess liquid flows out through the hole in the stopper which is then turned to close the hole. J. H. M. (*C. A.*)

107. New hardness tester. ANON. *Iron Steel Can.*, **6**, 145–8(1923).—A description is given of the Herbert pendulum hardness tester recently invented in England. This instrument gives direct and rapid readings of hardness and can be used for testing the hardness of substances ranging from Pb to sapphire. V. O. H. (*C. A.*)

108. Engineers develop pocket viscometer. ANON. *Nat. Petroleum News*, **15** [30], 92–4(1923).—A pocket viscometer consists of 2 bulbs, one carrying a standard liquid and the other the liquid to be tested. Viscosity in Saybolt sec. is read directly by the rate at which a sphere falls through each liquid. The accuracy of the instrument runs as high as 99% with an experienced operator. D. F. B. (*C. A.*)

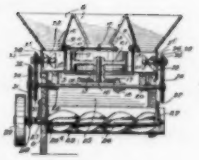


PATENTS

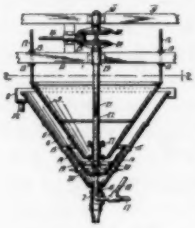
109. Rabble-furnace construction. BENJAMIN G. CALL. U. S. 1,465,417, Aug. 21. In a device of the class described, the combination of a rabble arm provided with a guide supporting member extending lengthwise thereof, a plurality of rabble guides slidably mounted on said member, adjacent sides of contiguous guides being provided with rabble supporting means, and a plurality of rabbles, each supported by said means between the contiguous guides whereby any pair of adjacent guides may be separated to permit the removal of the rabble carried thereby without affecting the mounting of the other rabbles.

110. Percentage feeder and mixer. ANGUS D. MACLELLAN. U. S. 1,462,649,

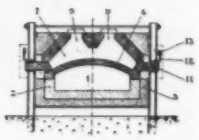
July 24. In a feeder of the class described, the combination with a base plate having recesses in its outer periphery, a wheel journalled to said plate, means between said recesses delivering different material laterally to said plate, and means on said wheel for conducting the material to said recesses.



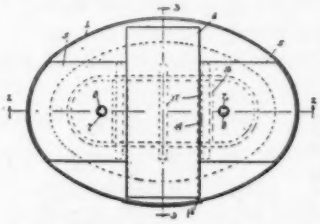
111. Ore concentrator. JOHN I. MULLEN. U. S. 1,465,143, Aug. 21. In an ore concentrator, the combination of an outer cone and an inner cone forming an annular channel for grading ore-particles carried in an aqueous medium into concentrates and tailings, an overflow conduit disposed to receive material passing across the upper edge of the outer cone, an intermediate cone dividing the lower portion of the channel into receiving and discharge compartments, means revolving in opposite directions in said receiving compartments for agitating the pulp, and means for receiving pulp to and discharging pulp from the respective compartments.



112. Electric furnace. MARIUS SAUVAGEON. U. S. 1,464,543, Aug. 14. An electric furnace, comprising a hearth the crown wall of which is formed of material which is a good conductor of heat and at high temperatures a good conductor of electricity, a series of heating chambers above said crown wall, granular resistance material filling said heating chambers, and electrodes extending into said chambers and contacting with said granular material. Cf. *Ceram. Abs.*, **1** [11], 279(1922).



113. Electric furnace. CHARLES A. CADWELL. U. S. 1,464,496, Aug. 14. In an electric furnace, the combination of an elongate furnace chamber; electrodes extending downwardly into such chamber one at each end; a resistor within said chamber lying on the floor thereof between said electrodes; and a muffle chamber supported at its ends in the respective side walls of said furnace chamber so as to lie over said resistor and between said electrodes, said muffle chamber being composed of a plurality of carbon rods plastered over with a layer of suitable heat-resistant material.



Kilns, Furnaces, Fuels and Combustion

114. The draft in rotary kilns. A. HEISER. *Tonind.-Ztg.*, **47**, 492(1923).—The damper in most fur. is usually left in one position owing to lack of knowledge of how to use it. H. describes the use of a draft gage to meas. draft in rotary kilns. By means of this gage the static and dynamic press. are recorded. Dynamic press. is the highest press. produced by a gas in motion and is represented by the following formula: $dp = YW^2/2g$ in which W is the velocity of the gas, Y the sp. gr. of the same, and g is the acceleration due to gravity which is 9.81 m. per sec. The total pressure pg is the algebraic sum of the static press. $pg = pst + pd$. If one meas. the total press. and the static press. in the same cross-section, the following holds true:

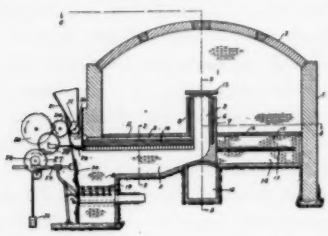
$$\frac{YW^2}{2g} = pg - pst,\ W = \sqrt{\frac{2g(pg - pst)}{Y}}\ \text{m./sec.}$$

An instrument made by the Schultze Co. (Berlin-Neukölln) is described. H. G. S.

115. A novel coal elevator. ANON. *Brit. Clayworker*, **32**, 108(1923).—An elevator for hoisting wheel barrows full of coal from the ground up to the top of a Hoffmann kiln is described. H. G. S.

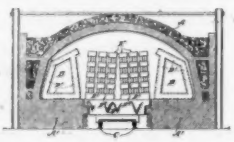
116. Coal distributors. ANON. *Brit. Clayworker*, **32**, 106–7(1923).—Coal distributors for feeding powdered coal into Hoffmann kilns are described. In hand feeding the burner visits and charges each feed hole about once every 20 min. The temps. rise considerably after each feeding causing fluctuations in temp. and overheating near the floor of the kiln. In the hand feeding of Hoffmann kilns it is difficult to get sufficient heat to the crown of the kiln. Most of these troubles can be overcome by using automatic pulverized coal feeders for introducing the coal. In this feeder the powdered coal is fed in minute rapid repeating quantities which raises the temp. of the kiln gradually, does not overburn the bottom, and causes the top to become as thoroughly heated as the rest of the kiln. Damage to brick lining of the feed holes is almost entirely prevented. The economy in fuel resulting from the use of this method was found to be from 20 to 30% over hand feeding. It is also claimed that lower grade fuels can be used in this method of feeding. H. G. S.

117. A car stopping device for tunnel kilns and driers. ANON. *Brit. Clayworker*, **32**, 110(1923).—It is frequently suggested that the opern. of a tunnel kiln or tunnel drier would be facilitated if the rail tracks were inclined downward toward the exit and instead of being laid level. In the latter case which is usual, a mechanical device is necessary to push the long train of cars along the track. This device can only be operated if the tunnel is full of cars and an additional car is ready at hand to be added to those already in place when the whole train is pushed forward. If the track is inclined the cars will travel by gravity to the exit end, the only requirement being a safety stop to prevent over-running when the whole train is in movement. A satisfactory stop for handling cars on an inclined track is described. H. G. S.

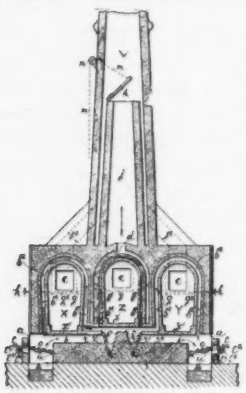


PATENTS

118. Kiln. ENOCH P. STEVENS. U. S. 1,465,744, Aug. 21. A kiln comprising a center flue for the admission of heated gases, a horizontal floor, means coöperating with said flue for deflecting gases downwardly toward said floor, apertures in said floor and a baffle wall placed below said floor for causing the heated gases to take a tortuous course in passing from said kiln.



119. Car for tunnel kilns. STEPHEN A. MITCHELL. U. S. 1,465,737, Aug. 21. A car for transporting bricks and analogous ware through a tunnel kiln comprising a body portion and pier-like goods supports thereon extending transversely to the direction of car travel and spaced apart to provide channels open at their outer ends and upper edges, said supports having their upper edges sloping downwardly from the sides of the car toward its center.



120. Kiln for firing pottery and other ware. CHARLES FREDERICK BAILEY. U. S. 1,465,573, Aug. 21. In firing app. of the class described, three kilns arranged side by side, a chimney common to the three kilns, the center kiln being provided with a horizontal heating flue extending

under it and a heating flue extending around it and communicating with the said chimney at its outlet end and with the horizontal flue at its inlet end, and the outer kilns having heating flues extending around them and communicating at their outlet ends with the said horizontal heating flue, and fire-places arranged at the outer sides of the outer kilns and provided with flues extending under the outer kilns and communicating with the inlet ends of their said heating flues and with the said horizontal heating flue. Cf. *Ceram. Abs.*, **2** [4], 81(1923).

121. Tunnel-kiln oil burner. GERALD ELLIS IRONS. U. S. 1,465,011, Aug. 14. An oil burner comprising an oil supply pipe with a restricted discharge orifice at its combustion end, a steam jacket surrounding said pipe with an annular discharge orifice surrounding the first mentioned orifice, and a non-metallic refractory shell surrounding the steam jacket and forming an air jacket for the latter, said shell having an air inlet at its outer end and having an opening at its inner end through which the discharges from said orifices may pass.

122. Induced-draft device. LOUIS PRAT. U. S. 1,465,683, Aug. 21. In an induced draft device for chimneys or the like, a plurality of fans, each adapted to deliver a substantially constant volume of fluid into the chimney, and a permanently open discharge nozzle of predetermined size for each fan, disposed in the chimney, to cause the fluid discharged by the fan to carry along the chimney gases in ejector fashion.

Geology

123. Problems in geology of service to ceramics. WIEGAND BRAUN. *Ber. der Deut. Keram. Gesell.*, **4** [1], 36–42(1923).—Examples are given of ways in which geol. sci. can be helpful to ceram., especially in the systematic uncovering of deposits of raw materials used in ceram. and in the development of useful new raw materials. It is also recommended that the ceram. indus. help support geol. research of value to ceram. E. N. B.

124. Kaolin in Mexico. ANON. *Chem. Age*, **9** [218], 14(1923).—The Mexican Govt. has made arrangements for working the numerous and extensive kaolin deposits existing in the country, which constitute an immense source of wealth. Hitherto no attempt had been made to work these deposits, which contain an inexhaustible supply of mat. for manuf. of the finest porcelain. O. P. R. O.

125. On clay. TOSHI SUZUKI. *J. Jap. Cer. Assoc.*, **370,** 310–4(1923).—Clays are classified in 2 groups, *i. e.*, (1) residual clay and (2) transported clay. Residual clay has chiefly been produced by weathering of feldspathic rocks, although it has often been produced by the action of hot spring or sulphurous vapors. 1. *Residual clays due to the action of weathering.* Clays of Hanasaka and Gokokuji (used in Kutani-ware) as well as that of Izushi (used in Izushi-ware) are kaolins from liparite. Gairome clays produced in the provinces of Mikawa, Owari, Mino and Iga are kaolins from granite. Very plastic reddish brown clay used in Onko-ware is a residue of a calcareous rock whose calcium carbonate has been dissolved away by weathering. 2. *Residual clays due to the action of hot spring or sulphurous vapors.* Some of clays used in the manuf. of Satsuma-ware were produced from augite-andesite by the action of sulphurous vapors and hot spring. Izumiyama clay used in Arita ware is a residue of liparite which was decomposed by the action of sulphurous gases. Tobe clay used in Tobe-ware was produced by combined action of hot spring and weathering on mica-andesite. Clays produced in the manuf. of Aizu-ware as well as amalgatolite of Mitsuishi were produced by the action of hot spring on liparite. 3. *Transported clays.* Fukushu clay is a fire

clay of coal measure. Kibushi clays found in Mino, Owari, Ise and Iga, those used in Banko- and Tokoname stonewares, clay used in Shigaraki-ware, raw material of Awaji faience and many clays used in the manuf. of crude faience as well as architectural potteries are of tertiary origin. Diluvial and alluvial clays are used in the manuf. of Takatori- and Imbe stonewares and most of crude faience, roofing tiles, sewer pipes, common brick, etc. S. K.

126. Diatomaceous earth produced in the Islands of Oki. DENZO SATO. *J. Jap. Cer. Assoc.*, **369**, 264–66(1923).—Geol. of the islands is given in detail. There are 3 large deposits of diatom. earth in the islands. Analyses of typical products are:

Deposit	Insol. matter	Sol. SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	Loss	Total
Iinoyama	43.93	37.51	1.17	3.06	0.00	0.19	0.57	0.28	13.06	99.77
Kamo	34.37	48.05	1.38	2.80	trace	.36	.32	.15	12.54	99.97
Minoura	34.25	46.32	0.75	3.60	0.00	.27	.63	.23	13.54	99.59

S. K.

127. Countries producing kaolins. ANON. *Chem. Age* (London), **9**, 11(1923).—*Great Britain.* True kaolins are found in two counties, Cornwall and Devon. The plastic "ball clays" are not to be confused with kaolin or china clay; these are employed in the manuf. of white wares, Dorsetshire. *France.* Deposits of kaolin occur in numerous districts of France. *Germany and Austria.* The kaolins of Ger. are of great industrial importance. *Saxony.* The earliest known occurrence of china clay in Europe was in Saxony. *Czechoslovakia (Bohemia).* Kaolin occurs associated with graphite; the principal area of exploitation lies between Mugrau and Schwarzbach. *Roumania.* Kaolinized formations occur in Roumania; these have not been worked. *Sweden.* The kaolins of Sweden are found in a comparatively limited area in the northern part of Scania (S. Sweden). *Denmark (Bornholm).* Kaolin is found at the foot of the granite plateau, north-east of Ronne. *Spain.* Kaolin-bearing rocks are fairly abundant in Spain, but nowhere are they exploited on a large scale. *Portugal.* In Portugal the name *tierra de vinos* is often given to kaolin. Kaolin-bearing sandstones are recorded in Portugal; also clean white kaolin which is employed for ceram. purposes and the clarification of wine. *Italy.* The kaolin industry of Italy is not well developed, active investigation might reveal many more deposits than at present known. *Russia.* Considerable deposits of kaolinic clays are found in S. Russia. *China.* The raw mat. of the porcelain industry of China possess a peculiar interest, as porcelain was here manufd. centuries before the first was made in Europe. *Japan.* The porcelain clays of Japan were discovered many centuries later than those of China. *India.* High grade kaolin rocks are scarce in India, but white clay is worked on a small scale for many purposes. *The Federated Malay States.* In the Federated Malay States, kaolin of a remarkable purity occurs abundantly. *Australia.* Kaolin mat. is not uncommon in Australia, but it does not appear to have serious commercial importance. *Canada.* China clay is worked in Canada 40 m. northwest of Montreal, Quebec. *United States.* The marketable kaolins of the U. S. are found in the Eastern States, fairly numerous and their value and importance is increasing. They show a great range of varieties, some high-grade clays, but few possessing the qualities peculiar to the best European kaolins. Several white clays are termed kaolins in the U. S., though they may not have the attributes of true kaolins, but may be ball clays, fire clays, or clays more suitable for stoneware. *Africa.* Kaolinized granitic rocks probably occur in many places in Africa, but none has been exploited for kaolin. In the Congo highly kaolinized granite and gneiss are found at the surface, and the kaolin washed therefrom has been employed by the natives as a whitewash. (From J. A. Howe's Handbook of Kaolins.) O. P. R. O.

128. Fluorspar mining in the western states. R. B. LADOO. U. S. Bur. Mines,

Repts. of Investigations, No. **2480,** 35 pp.(1923).—All the known fluorspar deposits of N. M., Ariz., Utah, Calif., Wash., Colo., and Nev. were examined. Descriptions of the individual mines, including their geology, mining and milling methods, flow sheets, and some analyses of the ore, are given. The deposits are so small, or so inaccessible, or the ore is so poor that profitable production of gravel grade of fluorspar, acceptable to eastern steel mills, is not likely to be possible. The production of acid fluorspar in these states, from known ore bodies, probably will not exceed 100 tons annually, that of ground fluorspar will not be more than 3000 tons. E. F. H. (*C. A.*)

PATENTS

129. Process for the manufacture of zinc white. ARMAND NIHOUL and C. CLERC. U. S. 1,463,483, July 31. In the process of manufacturing zinc white, precipitating the zinc in the state of carbonate, re-dissolving said carbonate in an acid solution, and further precipitating the zinc in the state of sulphide by means of hydrogen sulphide gas.

130. Process for the manufacture of alkali-metal silicates. CAMILLE DEGUIDE. U. S. 1,463,037, July 24. The process of producing alkali-metal silicates, which consists in decomposing barium silicate by water and an alkali-metal salt the acid radical of which forms a barium salt less soluble than barium silicate.

131. Manufacture of sodium fluoride. HENRY HOWARD. U. S. 1,464,990, Aug. 14. Process of making sodium fluoride which comprises simultaneously adding hydrofluoric acid and ammonia to a solution of sodium chloride. See following abs. Also *Ceram. Abs.*, **2** [8], 189(1923).

132. Process of making sodium fluoride. HENRY HOWARD. U. S. 1,464,991, Aug. 14. Process of making metal fluoride which comprises simultaneously adding hydrofluoric acid and ammonia to a solution of a salt of a metal which is more soluble than the fluoride of said metal at a relative rate sufficient to maintain the reaction mixture substantially neutral.

Chemistry and Physics

133. Determination of sulphate-, chloride-, and carbonate radicals contained in soda-lime glasses. MASAO IGAWA. *J. Jap. Cer. Assoc.*, **367,** 131–8(1923).—The author proposes the use of acid ammonium fluoride as decompn. reagent in the detn. of sulphuric anhydride, chlorine and carbonic anhydride contd. in glasses. 1. *Prepn. of ammonium fluoride, NH_4HF_2, for the detn. of sulphuric anhydride.* Silicon fluoride obtained by the action of sulphuric acid on ground quartz and ammonium fluoride is introduced into water. After filtering, the soln. is treated with an excess of ammonia, filtered through muslin and evapd. to dryness. Ammonium fluoride, thus obtained, is refined once more by sublimation. 2. *Prepn. of ammonium fluoride for the detn. of chloride.* Ammonium fluoride is purified by treating its soln. with silver nitrate. Then it is sublimed. 3. *Prepn. of ammonium fluoride for the detn. of carbon dioxide.* Ammonium fluoride is dissolved in water and treated with ammonia. The soln. is evapd. after filtration. 4. *Detn. of SO_3.* 3 g. of glass are mixed with about 9 g. of ammonium fluoride, and 5–6 cc. of water are added. The mixt. is evapd. to dryness, treated with sodium-carbonate soln. and filtered. The filtrate is once more evapd. to dryness. It is then extracted with 50% alcohol. The extract is evapd. to dryness, acidifying the soln. with oxalic acid. Sulphuric anhydride in the residue is detd. with barium chloride, after dissolving it with dil. HCl. 5. *Detn. of sulphur.* Total sulphur is detd. just as described above, but the sample must be decomposed in the presence of bromine. 6. *Detn. of Cl.* 5 g. of finely ground sample are mixed with about 15 g. of ammonium fluoride in a platinum basin. The glass is decomposed by adding 30 cc. of water to the basin and heating it at 60–70°C. Chlorine is detd. gravimetrically with silver nitrate, after removing silicic

acid with ammonia. 7. *Detn. of CO_2.* 15–20 g. of coarsely ground glass are put in a lead flask and decomposed by 25–30% soln. of ammonium fluoride. Carbonic acid gas liberated from the glass is absorbed by soda-lime, the app. and procedure being just like those of detg. carbonic acid gas in common carbonates by Fresenius-Classen's method. 8. *Examples of analyses.* Analyses of Belgian and American window glasses are:

No.	Na_2SO_4 (%)	Sulphur in forms other than sulphates, expressed as Na_2SO_4(%)	NaCl(%)	Na_2CO_3(%)
1	0.667	0.046	0.095	0.048
2	.908	.108	.071	.040
3	.068	.027	.154	.055
4	.960	.055	.151	.021
5	1.045	.000	.066	.051

S. K.

134. Fine and research chemicals. C. J. WEST. Nat. Research Council, *Reprint and Circular Series*, No. **44**, 45 pp.(1923); cf. *C. A.*, **16**, 195, 2633.—This is the second revision. It contains lists of American manufacturers, and of research chemicals, of biol. stains and indicators, of vital stains and of H-ion indicators that can be purchased in this country. E. H. (*C. A.*)

135. Silica studies. I. Loss of water of kaolin and its behavior in solid condition toward carbonates and oxides of alkaline earths. G. TAMMANN AND W. PAPE. *Z. anorg. allgem. Chem.*, **127**, 43–68(1923).—These expts. were undertaken on account of the very conflicting nature of the conclusions of other investigators. Data and curves are presented which were obtained in expts. on slimed and carefully washed Oschatz earth dried at 150°. These include dehydration, rehydration of material heated to 600°, behavior of $BaCO_3$ toward Al_2O_3 and kaolin, behavior of $CaCO_3$, $SrCO_3$, BaO, CaO and SrO toward Al_2O_3, SiO_2 and kaolin. Upon losing water at 550° kaolin decomposes into Al_2O_3, SiO_2 and water and at 930° the Al_2O_3, released at 550°, changes into another form less sol. in acids. These conclusions are based on the following evidence: (1) After loss of water at 550° the Al_2O_3 of kaolin is sol. in acids. (2) Heating to 800–900° renders both pure Al_2O_3 and that of kaolin difficultly sol. in acids. (3) Pure Al_2O_3 evolves notable amts. of heat between 850° and 1060°; kaolin at 930° evolves an amt. of heat which is proportional to its content in Al_2O_3. (4) After this evolution of heat the Al_2O_3 becomes denser and the kaolin shows a distinct increase of density. (5) Both Al_2O_3 and kaolin lower the dissociation temp. of alk. earth carbonates at 1 atm. about 220°. (6) Upon heating a mixt. of Al_2O_3 and SiO_2 heat evolution takes place at 940° as on heating kaolin and in both cases the Al_2O_3 becomes difficultly sol., but this same change of soly. is produced by heating Al_2O_3 alone. A. R. M. (*C. A.*)

136. Studies on clays. I. The acidic reaction of Japanese acid clays. TSURUJI OKAZAWA. *Bull. Inst. Phys. Chem. Research* (Japan), **2**, 189–221(1923).—K. Kobayashi has attributed the acidity of Japanese acid clay to its adsorptive action. O. has proposed a different explanation. Clays have many varied appearances and properties, but may be classified into 3 kinds from their reactivity to salt solns. and acids. When treated with salt solns. or strong acids, the first shows little or no soly., the second none for salt solns. but high with acids, and the third shows high soly. with both. Japanese acid clay belongs to the last class, but is not very different in compn. from common clays. When treated with salt solns., the positive radical in the neutral salt is drawn into the clay particle and Al in the latter is dissolved as a corresponding salt; *e. g.*, when $MgCl_2$ is used as the neutral salt, the reaction may be as follows: $R{:}Al.OH + MgCl_2 = R{:}Mg + AlCl_2OH$ and $AlCl_2OH + 2H_2O = Al(OH)_3 + 2HCl$, where R is the main radical in the clay; HCl thus produced gives the acidic reaction. This reaction is, therefore, considered to be attributed partly to adsorption and mainly to

double decompn. and the acidity is governed by the salt used, adsorptive and reactive affinities of the clay, stability of the reaction product and reaction velocity, etc. The value of the acidity is not definitely detd. by titrating with alkali. The so-called acidity of the acid clay is decreased greatly by burning at 700–800° for 1 hr. By heating, the state of mol. combination will be changed and Al_2O_3 in the clay will not be dissolved by salt solns. The relation between the burning and the quantity of Al_2O_3 dissolved from the clay by acid is opposite to the above relation. The higher the temp. of burning, the more Al_2O_3 is dissolved, the max. being at about 700–800°; the quantity dissolved is larger than that of other clay. At above 900° the quantity decreases quickly.

K. K. (*C. A.*)

137. The influence of fluxes on the transformations of quartz. N. PARRAVANO AND C. ROSSELLI DEL TURCO. *Gazz. chim. ital.*, **53**, 249–57(1923).—In previous work P. (*Ann. chim. appl.*, **10**, 150(1918)) clarified the nature of the transformations that take place in the burning of SiO_2 refractories, which consists substantially in converting quartzite into varieties having a greater vol., *i. e.*, tridymite, and cristobalite. This transformation occurs with or without the aid of the flux formed from the natural impurities present in the quartzite and of the lime used. After reviewing the existing information P. and T. describe their own expts. in which a quartzite (SiO_2 96.5, Al_2O_3 2.06, CaO 0.80%, Fe_2O_3 trace) was used to which 0.5, 1.0 and 1.5% oxides were added (Fe_2O_3, P_2O_5, B_2O_3, CaO and WoO_3). The brick were heated first 12 days at cone 15 (1430°) and then again for 15 days at cone 18 (1490°). The d. was detd. on the finely ground product. Microscopic examn. as well as the d. detns. showed under the conditions used, of which the absence of alkali was the most interesting, that B_2O_3 has the greatest accelerative action on the transformations of quartz even when only 0.5% is present. Its catalytic activity is so energetic that in practice it ought to be suitably weakened in order to be used advantageously. Fe_2O_3 has a notable catalytic action, perhaps through the formation of silico-ferrites as well as silico-aluminates (from the Al_2O_3 always present) giving mixts. fusible at temps. not too high. In this case the d. does not reveal the phenomena as well as the microscopic observations. E. J. W. (*C. A.*)

138. Adsorbent properties of clay. M. A. RAKUSIN. *Chem.-Ztg.*, **47**, 115(1923).—Ordinary clay, especially when ignited, possesses adsorbent properties similar to those of kaolin. A 1% soln. of petroleum in petroleum spirit, colored a deep reddish brown, was completely decolorized by standing for 24 hrs. in contact with 5% of ignited clay or 8% of air-dried clay. Suspensions of indigo in aromatic hydrocarbons were colored yellow after this treatment, while suspensions of indigo in petroleum spirit, kerosene, and vaseline oil were colorless. Aromatic hydrocarbons extd. from air-dried clay a yellow oil, insol. in petroleum hydrocarbons. This oil is probably derived from straw and manure kneaded into the clay during its prepn. J. S. C. I.

139. Synthetic aluminium silicate and its relations to kaolin. ROBERT SCHWARZ AND ALBERT BRENNER. *Ber.*, **56B**, 1433–7(1923).—When dil. neutral aq. solns. of $AlCl_3$, and Na_2SiO_3 are mixed in the ratios varying from 1:0.75 to 1:5 the proportion of SiO_2 in the ppt. increases until the compn. $Al_2O_3.2SiO_2 + 2H_2O$ is obtained after drying at 110°. This ppt. differs from kaolin in that it is comparatively easily decomposed by concd. HCl and loses H_2O at a lower temp. X-ray spectrographs show that 2-day-old and 8-day-old samples were amorphous but that after 8 days a cryst. structure, similar to that of kaolin had developed. D. MACR. (*C. A.*)

140. Influence of surface tension on melting and freezing. ERNST RIE. *Z. physik. Chem.*, **104**, 354–62(1923).—A mathematical paper. The influence of surface tension on the m. p. is investigated thermodynamically, and formulas are deduced for the change in the m. p. A new theory of the structure of glasses is given, and the difference between this and that of Tamann is discussed. H. J. C. (*C. A.*)

141. New diagrams for the valuation of fuel gas and flue gas analysis. WILHELM SCHULTES. *Die Wärme*, **45**, 213–8; *Chem. Zentr*, **1922**, IV, 684.—The diagrams of Ostwald, Seufert and Krämer are complicated in form, are too exact for technical work and do not permit direct graphical readings of the heat losses. By simplifying the formula upon which they are based, a similar representation of the combustion triangle is derived, with diagrams which allow a direct valuation of analysis. C. C. D. (*C. A.*)

142. The three-component system: lime, silica and alumina. R. GRÜN AND K. BIEHL. *Zement*, **12**, 10–1, 18–9, 26–7, 34–5, 44–5, 111–3, 120–1, 126–7(1923).—A phase-rule diagram and a space diagram of the system CaO, SiO_2, and Al_2O_3 are given. $3CaO.SiO_2$, $2CaO.SiO_2$, $3CaO.2SiO_2$, and $CaO.SiO_2$ are the compds. formed by CaO and SiO_2. $3CaO.Al_2O_3$, $5CaO.3Al_2O_3$, $CaO.Al_2O_3$, and $3CaO.5Al_2O_3$ are formed by CaO and Al_2O_3. $Al_2O_3.SiO_2$ is formed by Al_2O_3 and SiO_2. $2CaO.Al_2O_3.SiO_2$ and $CaO.Al_2O_3.2SiO_2$ are formed by the 3 substances. Photomicrographs have been made of various mixts. of the system which show that all of the above compds. have definite cryst. structures. The phys. properties of all the compds. are given. R. F. S. (*C. A.*)

143. Graphic method for computing heat balance. F. A. SHORKEY. *Blast Furnace & Steel Plant*, **11**, 348–54(1923).—A series of graphs is given to replace the use of formulas for boiler-room computations. The charts are based on no CO present and a max. of 19% CO_2, and include (1) detn. of H (2) detn. of volatile C (3) losses due to H_2O (4) losses due to burning of H (5) losses due to combustible in ash and S correction (6) losses due to heat in dry flue gases and (7) losses due to CO in dry flue gases.
C. C. D. (*C. A.*)

144. Estimation of iron in ores and silicate rocks. F. R. ENNOS AND R. SUTCLIFFE. *Summary of Progress Geol. Survey*, **1921**, 174–6.—In the case of samples contg. Fe, Al, Ti and phosphate, fuse the weighed oxides of the Al group with pyrosulfate and est. the Ti colorimetrically in the soln. resulting from the fusion. Then evap. the soln. to a vol. of about 100 cc., destroy the excess of H_2O_2 by treating the hot soln. with the required quantity of H_2SO_3, and sat. the soln. at 90° with H_2S. Sep. the ppt. of S and Pt sulfide (the Pt is derived from the crucible in which the fusion was made) by filtration and wash with very dil. H_2SO_4. Cool the filtrate, oxidize with dil. $KMnO_4$ soln., add 10 cc. of concd. HCl and 5 cc. of 20% NH_4CNS soln., and titrate the Fe with standardized $TiCl_3$ soln. J. C. S. (*C. A.*)

145. Surface tension and adsorption phenomena in flotation. A. F. TAGGART AND A. M. GAUDIN. *Trans. Am. Inst. Min. Met. Eng.*, **68**, 479–535(1923).—Surface tension measurements are described. Frothing is caused by the sol. constituents of the agent. A change of surface tension of the solvent by the solute produces the frothing. When ore is added the viscosity of the mixture is increased and the froth becomes more permanent. The surface tension is not affected in any way by an insol. oil, such as Nujol. The behavior of various flotation oils at the water surface is studied. The adsorption properties at liquid and solid surfaces were studied by using the froth formed and the rejected soln. W. A. M. (*C. A.*)

146. New data on thermochemistry. WOJCIECH SWIENTOSLAWSKI. *Bull. soc. chim.*, **29**, 496–9(1921).—Combining his own results (*C. A.*, **5**, 1414, 1415; *Bull. Acad. Sci. Cracow*, **1909**, 941–72) with those of Fajans (*C. A.*, **14**, 1623), S. deduces values for the heat of formation of any linking such as $(C-X)$ or $(H-X)$ and shows that it may be considered as made up of two parts, one part being produced by the atom $(C-)$ or $(H-)$ and the other by the atom to which it is linked. Values are calcd. for C and the halogen atoms. It is shown that the heat produced by the atom in the formation of a compd. $X-Y$ is not always equal to the heat produced by it in the formation of the simple mol. $X-X$. J. C. S. (*C. A.*)

General

147. Utilization of a waste alumina. IWAZO TAKITA AND MASAJIRO WATAYA. *J. Jap. Cer. Assoc.*, **366,** 98–108(1923).—The research relates to the utilization of impure alumina which is obtained as a waste product in the process of extracting alum from calcined alunite. The waste alumina of the Asada Alum Works, Shikama, Harima, has been used in the expts. 1. *Properties of the waste alumina.* Analysis of the waste alumina is: SiO_2 28.50, Al_2O_3 65.33, Fe_2O_3 0.56, CaO 1.25, K_2O 1.80 and SO_3 2.46%. Refractoriness is over cone 37. 2. *Manuf. of chem. porcelain.* Expts. on the manuf. of chem. porcelain with 7 different bodies and 7 glazes are described. The best result for cone 16 was obtained with No. 1 body and *e* glaze. No. 1 body was composed of 23.2 waste alumina, 33.7 gairome-clay of Tokiguchi, 25.0 ohmishima quartz and 18.1% ohmishima feldspar. Its formula is $0.1036K_2O, Al_2O_3, 3.1303SiO_2$. Small crucibles were formed by casting a slip composed of 100 raw materials, 0.25 sodium carbonate, 0.08 water-glass and 90 water. The glaze which was applied on their biscuits is $\left.\begin{matrix}0.1K_2O\\0.9MgO\end{matrix}\right\}1.0Al_2O_3, 10.0SiO_2$ in which MgO was added in form of calcined magnesite. The glazed biscuits were fired at cone 16. The products stood various tests better than German crucibles. 3. *Manuf. of glass pot.* Small pots made of 18 different bodies by casting and fired at cones 010a, 8 and 15 were filled with a glass mixt. composed of 38.22 cryst. borax, 12.40 boric acid, 92.04 barium oxide and 36.00 sand; they were heated at cone 8 to compare their resistance to corrosion. Detailed descriptions are given on the procedure and results of the expts. 4. *Manuf. of refractory brick.* Superior brick were obtained by the following process: The waste alumina is ground, pressed into briquettes, fired at cone 18 and reground; brick made of 80% grog and 20% raw Kibushi-clay are fired at cone 16. Their shrinkage was 0.44% in drying and 0.33% in firing. Their refractoriness was over cone 37. S. K.

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A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical and Scientific Questions and Promotion of Coöperative Research

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Vol. 2 **November, 1923** **No. 11**

EDITORIAL

INDEBTEDNESS

An honest and honorable person abhors indebtedness unless there is profit to be gained in its assumption and payment. Each person owes to self and to others certain obligations which, if not acknowledged and discharged, become abhorent.

No service is rendered for which a compensation of some sort is not due. Those who receive service, whether wittingly or otherwise are obligated to pay the compensation which that service has made due. The welfare of man in all particulars is dependent on the extent and promptness with which these obligations are recognized and discharged.

How about indebtedness to one's fellow men and to society in general? Is a person obligated to his city, state and nation; to his posterity? To the point of this editorial—has a person an obligation to his profession or to his industrial fellow that is not a basic obligation to self?

Each person in a community profits from a strong, virile and progressive government, school and church. The K. of C., the Y. M. C. A., and the many social, religious, and educational institutions have made living more pleasant and profitable to each and every person. It is profitable alike to the childless and to the parent that good schools are maintained. It is beneficial to each person that no money or effort be spared to keep well

and alive every human being. For all of these benefits each person is obligated to pay his quota in support of the means employed.

How about one's interests and obligations in the welfare of his industrial fellows? Does it profit a person who is engaged in ceramic work to maintain strong and virile educational institutions devoted exclusively to the ceramic arts and sciences?

Those who are informed of the facts know that the ceramic industries as a whole and that each firm or corporation separately have profited and continues to profit a great deal from the researches reported through the AMERICAN CERAMIC SOCIETY and from the gathering together in its conventions for the purpose of discussing technical plant problems. This SOCIETY is an organized corporation and a membership implies an obligation to coöperate for mutual profit, but this obligation rests with all ceramic workers and firms in as much as the profits do actually accrue to all.

The Program Committee has issued a call for contributions to the convention program. This is an opportunity for each member to discharge the obligation he owes to his fellows on account of the hundreds of valuable contributions which have been given by others during the past twenty-six years. This opportunity is not for an exclusive few; it is for all members.

The Membership Committee has drawn attention to the opportunity to serve self by inviting others to join this coöperative educational enterprise. The SOCIETY does not need joiners, but it does need an extension of its opportunities for service and the opportunity and strength to make its services of more value to each member. These larger opportunities for service can be had only through a larger membership.

President Greaves-Walker, Messrs. Zopfi, Flint, Riddle and others have drawn to the attention of corporations their opportunity for self service in corporation memberships by thus making possible and more effective these organized educational opportunities to their employees.

The obligation of each ceramist and of each ceramic concern is obvious The AMERICAN CERAMIC SOCIETY is the agency through which these obligations may most easily and most effectively be discharged.

The convention program—the membership invitation—the corporation membership support—the perpetual membership endowments—these are opportunities for discharging the indebtedness you owe to yourself and to your fellow ceramists.

ACTIVITIES OF THE SOCIETY

PRESIDENT'S PAGE

We have reached the crucial point in the year so far as our finances are concerned. From this time until the first of the year when the 1924 dues begin to come in the outgo will exceed the income.

When the Budget Committee decided last year to lay out a program calling for an expenditure of $40,000 they foresaw the necessity of drawing upon the last of our financial reserves to make up a certain deficit. Every business man knows, however, that additional investment is always necessary to enlarge a business and the Budget Committee decided to invest in order to enlarge and extend the SOCIETY.

That their decision was wise is now beyond doubt, as this year will prove to be the greatest in the history of the SOCIETY both as to growth and accomplishments.

Every effort must be made by every member to increase the membership and advertising, the only two sources of income that can help us during the balance of the year to reduce the deficit.

Next year we must budget at least the same amount as this year if not more. The time has arrived when the SOCIETY should have an Editor so as to release the Secretary for the tremendous amount of work that lies before him. This would mean an additional $3000 or $4000 per year, but it would be worth all we put into it.

* * *

Splendid response has been received from the various committees and the real work of the year has begun. Difficult as it is to carry on committee work, much can be accomplished by a live chairman and it is to these chairmen we are looking for results before February 1st.

* * *

Have you thought of taking out a perpetual personal membership? Many members can easily afford the $200 fee and it would be a splendid thing to be among the first to contribute to the SOCIETY'S endowment.

* * *

In addition to the splendid entertainment given the members at the Summer Meeting the Detroit Section has put itself decidedly on the SOCIETY'S map by holding a large and successful meeting at which many members of other technical and engineering societies were present. I know it will give every member pleasure to know that another Section has been so successfully launched.

NEW MEMBERS RECEIVED FROM SEPTEMBER 15 TO OCTOBER 15

PERSONAL

A. R. Anderson, 607 Int. Southern Bldg., Louisville, Ky., President Kentucky American Clay Company.

J. Antonio de Artigas, 4 Arrieta, Madrid, Spain, Scientific Glass Laboratory.

John Betteley, 314 Fielding Ave., Ferndale, Mich., Clay Inspector and Thrower.

W. A. Darrah, 79 W. Monroe St., Chicago, Ill., Consulting Engineer.

George E. Ford, 50 Church St., New York, N. Y., District Sales Manager, A. P. Green Fire Brick Company.

Pierce W. Ketchum, 203 Ceramics Bldg., University of Illinois, Urbana, Ill., Research Graduate Assistant.

William H. Leary, 907 E. 75th St., Chicago, Ill., Advance Pyrometer Service Company.

George W. Lester, 2176 McClellan Ave., Detroit, Mich.

Robert Macdonald, Jr., General Abrasive Company, Niagara Falls, N. Y., Metallurgist.

Frank Cameron Schultz, 348 Chittenden Ave., Columbus, Ohio (Student Member).

E. L. Simpson, 20th and State St., East St. Louis, Ill., Production Engineer, American Range and Foundry Company.

George A. Speer, 116 Hyland Ave., Ames, Iowa (Student Member).

S. D. Swan, 220 West 42nd St., New York, N. Y., Research Chemist, The Dentist's Supply Company.

Marion I. Walter, 3226 Warder St., N. W., Washington, D. C., Ceramic Division, U. S. Bureau of Standards.

Guy A. Young, 33 Elmwood Ave., Bloomfield, N. J., Engineer, Capstan Glass Company.

CORPORATIONS

Crane Enamelware Company, Chattanooga, Tenn., H. W. Powell, Gen. Mgr.

Wishnick Tumpeer Chemical Company, 365 E. Illinois St., Chicago, Ill., Michael Agazim, President.

Membership Committee boosters have the following record:

Name	Personal	Name	Personal	Corporation
E. N. Bunting	1	Henry J. Mitchell	2	
Edward Burkhalter	1	D. A. Moulton	1	
G. W. Cooper	1	James T. Robson	1	
H. D. Foster	1	H. E. Davis		1
H. S. Kirk	1	Office	5	1
John J. Maroney	1		—	—
			15	2

No resignations, Net Gain 17

Personal	Corporation	Total Roster Oct. 15
1862	254	2116

PERSONAL NOTES OF SOCIETY MEMBERS

M. G. Babcock, formerly sales representative of the Laclede-Christy Clay Products Company has succeeded P. M. Offill in charge of their Pittsburgh office.

George A. Balz has asked that his address be changed from Rahway, N. J., to Perth Amboy, N. J.

Harry Barkby, formerly manager of the Chelsea China Company, New Cumberland, W. Va., has a similar position with the Warwick China Company, Wheeling, W. Va.

Charles E. Bates has taken a position with the Beaver Falls Art Tile Company, Beaver Falls, Pa. Mr. Bates was previously with the National Fire Proofing Co., of Perth Amboy, N. J.

A. G. C. Breese has moved from Bridgeton, N. J., to 135 Bridge Street, Manchester, Mass.

Trevor Caven, who has been consulting engineer with the Quigley Furnace Specialties Company is now located at 564 W. 173rd St., New York, N. Y.

Sanford S. Cole, formerly of Hornell, N. Y., is now located at 203 Ceramics Bldg., Urbana, Illinois.

R. R. Danielson, Secretary of the Enamel Division of the AMERICAN CERAMIC SOCIETY, has returned to the Bureau of Standards, Washington, D. C., having resigned his position with the Beaver Enameling Co., Ellwood City, Pa.

Redfield Dinwiddie, until recently ceramist for the Babcock and Wilcox Co., East Liverpool, Ohio, is now living in Somerville, N. J.

A. H. Fessler has accepted a position as manager of the Hamilton Clay Manufacturing Company, Hamilton, Illinois. Mr. Fessler has been with the U. S. Bureau of Mines on the laboratory car "Holmes."

G. M. Galvin, recently of the U. S. Naval Fuel Oil Testing Plant, Navy Yard, Philadelphia, Pa., is now with the Jointless Fire Brick Company, Trenton, N. J.

T. W. Garve has moved from Brazil, Ind., to Washington, Pa. Mr. Garve is employed with the Findlay Clay Pot Company.

Robert E. Gould, formerly of Columbus, Ohio, is now living at 512 E. 2nd Street, Flint, Mich.

Ralph E. Hanna has moved from 149 Rector Street, to 272 McClelland Street, Perth Amboy, N. J.

M. E. Holmes has taken a position with the United States Gypsum Company, 205 West Monroe St., Chicago, Illinois. Mr. Holmes has been manager of the chemistry department of the National Lime Association, Washington, D. C.

Karl M. Kautz, 1923 graduate in ceramics, Ohio State University, is now with the American Range and Foundry Company, St. Louis, Mo.

J. H. Knote, whose address has been unknown for some time has notified the Secretary's office that he is with the J. H. Gautier Co., Jersey City, N. J.

Raymond B. Ladoo, of the Southern Minerals Corporation who has been located at the Washington, D. C. office will have his headquarters during the winter at Cleveland, Tenn.

Walter T. Lippert has moved from Alton, Ill., to 85 North Laurel St., Bridgeton, N. J.

G. F. Metz, sales manager of the Hardinge Company has been transferred from the New York office to York, Pa.

L. V. Reese is now corporation representative for the U. S. Metals Refining Company, taking the place of Francis R. Pyne who has left that company.

L. M. Richard has moved from Ocean Park, Calif., to 1032 7th St., Santa Monica, Calif.

Malcolm A. Schweiker, general manager of the Empire Floor and Wall Tile Company of New York City is now located at the Worcester, Pa., office.

W. L. Shearer, of the Ceramic Division, Bureau of Standards, Washington, D. C., has accepted a position as instructor in the Department of Ceramics at Rutgers College, New Brunswick, N. J.

George C. Swift has moved from 2029 E. 115th St., to 1031 Greyton Rd., Cleveland, Ohio.

Royal W. Taylor, of the Canton Stamping and Enameling Company, has moved from 707 12th Street, N. W., to 1415 Arnold Ave., N. W., Canton, Ohio.

Robert Twells, Jr. has moved from Highland Park, Mich., to 309 Ardmore Drive, Ferndale, Mich.

C. A. Underwood, formerly of the General Refractories Company, is now with the Queen's Run Refractories Co., Inc., 141 Milk St., Boston, Mass.

Ernest W. Westcott has left the Niagara Falls Alkali Company as Research Engineer and is now with Kalmus, Comstock and Westcott of Niagara Falls, N. Y.

Stefan Wiester has moved from Belleville, Illinois, to 1903 S. 4th Street, Ironton, Ohio.

A. E. Williams, Secretary of the Glass Division, AMERICAN CERAMIC SOCIETY, has left the Bureau of Standards, Washington, D. C., and is located in Elmira, N. Y., with the Thatcher Manufacturing Company.

ORGANIZATION OF DETROIT SECTION

BY H. F. ROYAL

At the request of A. F. Greaves-Walker a section of the AMERICAN CERAMIC SOCIETY for the Detroit district has been organized by Frank H. Riddle. When the organization of this section was contemplated it was realized that a large, very active section could not be built up by appealing solely to the members in the Detroit district, because these members are too widely scattered. A large, active section could be assured through discussions of vital and general interest to Detroit's gigantic industries. The subject of most interest clearly was refractories.

The Detroit district uses millions of fire brick yearly and many Detroit plants are engaged in writing specifications for the purchasing of refractories. It was decided, therefore, to have as the subject for discussion at the first meeting "Specifications for Refractories." A. V. Bleininger kindly agreed to deliver the address on this subject.

A banquet preceded the first meeting held on October 4 and eighty men responded to the several hundred notices which were sent out. Mr. Riddle acted as temporary chairman. The Kentucky Fire Brick Manufacturers' Association was represented and men were present from many of the large plants including the Ford, Dodge Brothers, Cadillac, Hudson, Maxwell, Packard, Timken Axle plants and others; the Detroit Edison and Detroit City Gas Companies were well represented; Professors Peck and Kraus of the Mineralogical Department were present; five members of the SOCIETY came from Flint and Mount Clemens; and fifteen men were present representing various sales offices in the district. The sales offices and manufacturers' representatives displayed a great interest in the meeting and were responsible for the presence of several interested men.

Mr. Riddle outlined the aims of the SOCIETY and the purposes in view in the formation of a local section. His remarks were followed by short speeches and expressions of interest by many of those present. It was clearly evident that the men present were really interested in the SOCIETY and in the support of a local section. A motion was carried unanimously that such a section be formed. The following men were nominated by Robert Twells and were elected to serve for one year:

A. B. Peck, Chairman
P. D. Helser, Vice-chairman
H. F. Royal, Secretary-Treasurer
F. H. Riddle, Councilor

Dues were set at one dollar a year.

Mr. Bleininger's address was followed by a brief discussion.

Two more meetings on the subject of "Refractories" are being planned. The list of members in the Detroit Section is given below:

E. B. Baker, Detroit-Star Grinding Wheel Co. Detroit, Michigan.
H. Bill, Champion Porcelain Co., Detroit, Michigan.
J. Betteley, Champion Porcelain Co., Detroit, Michigan.
K. Boyne, Ford Motor Car Co., Highland Park, Michigan.
W. A. Carter, Detroit Edison Co., Detroit, Michigan.
W. J. Cluff, F. B. Stevens, Inc. Detroit, Michigan.

J. Disney, F. B. Stevens, Inc., Detroit, Michigan.
R. C. H. Duclor, F. B. Stevens, Inc., Detroit, Michigan.
J. F. Gottron, Smith, Gottron, Berry Corp., Detroit, Michigan.
S. E. Hemsteger, Mt. Clemens Pottery Co., Mt. Clemens, Michigan.
P. D. Helser, A-C Spark Plug Co., Flint, Michigan.
O. W. Kraft, c/o Wolverine Porcelain & Enameling Co., Detroit, Michigan.
H. M. Kraner, A-C Spark Plug Co., Flint, Michigan.
G. S. Kennelley, Detroit, Michigan.
M. D. Lucas, Detroit, Michigan.
C. R. Moore, Champion Porcelain Co., Detroit, Michigan.
J. E. Purtell, Ashland Fire Brick Co., Ashland, Kentucky.
F. H. Riddle, Champion Porcelain Co., Detroit, Michigan.
J. W. Rollinson, Detroit, Michigan.
W. C. Steif, Mt. Clemens Pottery Co., Mt. Clemens, Michigan.
A. I. Snyder, Detroit City Gas Co., Detroit, Michigan.
R. A. Smart, Detroit, Michigan.
R. Twells, Champion Porcelain Co., Detroit, Michigan.
A. A. Treadway, Detroit, Michigan.
J. Watt, Ford Motor Car Co., Highland Park, Michigan.
L. E. Worthing, Detroit City Gas Co., Detroit, Michigan.
Taine McDougall, A-C Spark Plug Co., Flint, Michigan.

CALIFORNIA LOCAL SECTION TO ORGANIZE

The temporary organization of the new California Local Section of the AMERICAN CERAMIC SOCIETY was effected on October 15 at Los Angeles. Fifty men interested in the Ceramic industry were in attendance and all very eager to bring about this organization. In addition to this number about twenty men in the San Francisco district have expressed their desire to coöperate in this Section and undoubtedly will become members of the Section. The petition was signed by forty-four members. The temporary officers for the organization are:

President, A. Malinovszky
Vice President, G. R. Boggs
Secretary-Treasurer, T. S. Curtiss
Councilor, F. B. Ortman

MEETING OF THE COMMITTEE ON STANDARDS[1]

The Committee on Standards met on September 19, 1923 in New York City at Grand Central Palace. The following members of the Committee attended: R. F. Geller, Chairman, M. C. Booze, E. C. Hill, W. T. Stephani, R. M. Howe. R. C. Purdy was also present at this meeting.

The Committee was addressed by the chairman relative to the importance of the work on specifications and need for combined and unstinted efforts, on the part of every committee member, to expedite the establishment of specifications. The question of rearranging the committee into two groups, the first consisting of the chairman and four members of the SOCIETY who are actively interested in the technical phase of Ceramics to function as the Standards Committee proper, and the second group to be composed of the chairman, together with the several divisional Standards Committee chairmen, to

[1] By R. F. Geller, Chairman.

function as an advisory group, was discussed. The plan was favorably received, but the committee was advised that the present organization was written into the Constitution of the SOCIETY.

The subject of specifications was then taken up by the committee and the following business transacted:

A. It was passed that the Suggested Specifications for Whiting be revised to allow a maximum of 2% magnesium carbonate in class 1 whiting, and that the revised form be submitted to the General Secretary for vote with the recommendation that they be adopted as standard.

B. It was passed that the Proposed Tentative Specifications for the Purchase of Flint be resubmitted to the Divisional Committee by the General Secretary with the following suggestions and recommendations:

(1) That the manufacturer state the original form of silica from which the flint was obtained.

(2) That it be specified that the flint be shipped in paper lined cars.

(3) Regarding lime content that the specifications read, "not more than" the required per cent in order to provide for some variation.

(4) That the specifications be changed to include revisions suggested in the published discussion.

(5) That further consideration be given to the specifications for the determination of calcined color and fusing temperature.

(6) That provision be made for retest.

(7) That the specifications be submitted to the producers for consideration.

(8) That the specifications be put into a general or standard form, such as has been adopted for all AMERICAN CERAMIC SOCIETY specifications. It was further recommended that the placing of the specifications in their final form be deferred until the Bureau of Standards has completed its present investigation on the Effect of Various Types of Flint on Whiteware Bodies.

C. It was passed that the Tentative Specifications for Feldspar be resubmitted to the Divisional Committee with the following recommendations:

(1) That a special committee be appointed to devise a method for the determination of the relative viscosity of feldspar.

(2) That further consideration be given to the K_2O and Na_2O ratios as given in the specifications.

(3) That the specifications be so worded as to make clear the fact that a, b and c grades do not imply materials of decreasing quality.

(4) That the specifications be put into standard form.

D. Recommended Specifications for Limestone, Quicklime and Hydrated Lime.

It was passed that these specifications be submitted to the General Secretary for vote by the SOCIETY.

E. Tentative Specifications Published in 1921–22 Year Book.

(1) Regarding Proposed Method for Sampling of Clay Deposits it was passed that J. Spotts McDowell be appointed a special agent to devise a more satisfactory method of sampling.

(2) Tentative Method for Sampling Ceramic Materials as Delivered. Under item (3) it was passed that this be revised to read "the standard gross sample shall not be less than 0.1% of the total shipment." It was further passed that this Method in the revised form be submitted to the General Secretary for vote by the SOCIETY as standard.

(3) It was passed that Tentative Methods for Chemical Analysis, Slag Test and Transverse Strength be further considered by the committee.

(4) It was passed that the Method for Slaking be submitted to the General Secretary for vote by the SOCIETY as standard.

(5) It was passed by the committee that the Scale for Testing Sieves be submitted to the General Secretary for vote by the SOCIETY as standard.

(6) It was passed by the committee that the Tentative Definitions for Clay Refractories be submitted to the General Secretary for vote by the SOCIETY as standard.

(7) Tentative Methods of Testing Electrical Porcelain. It was passed by the committee that this be resubmitted to the Divisional Committee with the recommendation that F. H. Riddle be appointed special agent to reconsider them.

(8) Tentative Method of Test for Refractory Materials under Load at High Temperature It was passed by the committee that this be submitted to the General Secretary for vote by the SOCIETY as standard.

(9) The committee decided to give further consideration to methods and apparatus published in the Appendix.

Following this business the committee adjourned. The next meeting will be held at the time of the Annual Meeting of the SOCIETY in February, 1924, at Atlantic City.

NOTES AND NEWS

EDWARD ORTON, JR., NOW BRIGADIER-GENERAL

Military Record

Sergeant Major, 6th training Regiment, Citizens Training Camp, Plattsburgh, N. Y., August, 1916.

Commission to Major Quartermaster Corps, Officers Reserve Corps, July 5, 1917.

Called to active duty, Fort Sam Houston, Texas, May 9, 1917, assigned to Motor Transport Division, Quartermaster Corps.

Transferred to Washington, D. C., August 18, 1917, office of the Quartermaster General in charge of Engineering Section, Motor Transport Division.

Promoted Lieutenant-Colonel, in charge Service Division, Motor Transport Corps, September 6, 1918.

Awarded Distinguished Service Medal for service in standardization of motor trucks and equipment, May, 1919.

Discharged, June 2, 1919.

Commissioned Colonel, Quartermaster Corps, Officers Reserve Corps, September 12, 1919.

Courtesy Harris & Ewing

BRIGADIER-GENERAL EDWARD ORTON, JR.

Commissioned Brigadier-General, Quartermaster Corps, Officers Reserve Corps, September 27, 1923.

AUTOGRAPHIC EXPANSION APPARATUS

For Measurement of the Temperature Coefficient of Expansion of Any Material Available in Rod Form

General

The difficulty of accurately measuring the thermal expansion of metals, glass, porcelain and other solid material by previously existing methods has led to the development of a new piece of apparatus inherently accurate and extremely simple.

The measurement of the temperature coefficient of expansion by most existing methods shows a result applicable to only one temperature and does not give a complete picture of the expansion characteristics over a complete temperature range. The apparatus described below does give such a picture in a thoroughly comprehensive form.

Description

Figure 1 gives a general idea of the appearance of the instrument. It consists essentially of a camera mounted on a common base with an electrical heating unit and

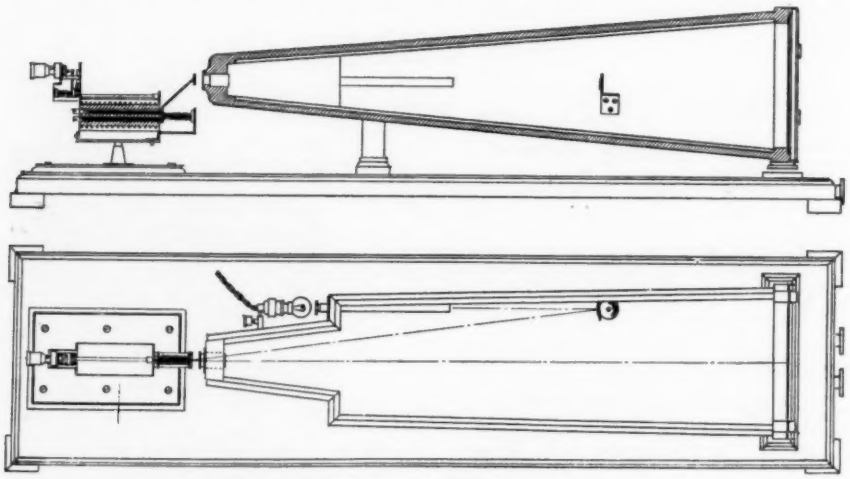


FIG. 1.—Sketch of expansion apparatus.

an adjustable source of illumination. The over-all length is approximately 48 inches, height 12 inches, width 13 inches. The electrical heating unit is wound on an iron core. It is provided with a thermostatic device and an auxiliary automatic switch so that at a temperature of about 200°C an auxiliary resistance is automatically cut out and at the temperature at which the test is to be discontinued the current to the heating unit is automatically cut off.

In the core of the heating unit are four holes running through it: one is to receive a thermocouple for accurate determination of temperatures; a second contains a quartz glass rod 10 cm. long which is the standard against which comparison of the sample is made. A third contains a standard metal rod with known expansion such as platinum or constantan. The fourth is to receive the sample rod which is to be tested.

One end of each rod is held against an adjustable screw at the back of the furnace; the other end is ground to a conical shape and is free to expand. The points of these

rods are held against a plate which is pressed against them by a coiled spring. To this plate is fixed a mirror by a suitable support. The expansion of the rods with respect to one another creates a movement of the plate pressed against them which in turn is conveyed to the mirror. The movement of the rod with known expansion, *i. e.*, either platinum or constantan, creates a movement so that a beam of light which is reflected by the mirror moves in a horizontal direction. The expansion of the rod which is being investigated creates a movement of the mirror which deflects the light in a vertical direction. The resulting graph is, therefore, a curve of which the horizontal ordinate corresponds to temperature and the vertical ordinate corresponds to expansion. The constants of the apparatus give a magnification of approximately 165 times.

The lamp which provides the beam of light has an adjustable screw and shutter, etc., so that the proper degree of illumination is readily obtained. The adjustment screws holding one end of the rods provide a means so that the test is started with the beam of light focused on the lower right hand corner of the ground glass objective plate. Sensitized photographic paper with millimeter cross-section lines is used exactly as a plate is used in a camera.

When the rods and light are adjusted, a plate holder is inserted in the back of the camera, the slide removed and the furnace started. The thermostat is then set at the temperature where the test is to be discontinued. The operator watches his pyrometer instrument and drops the shutter in front of the illuminating bulb at regular temperature intervals such as 100° or 200°. This shuts off the light for a brief interval causing a blank space about 1 mm. long on the photographic reproduction.

From the foregoing description it will be seen that the apparatus is almost completely automatic, entirely so except when accurate temperature measurements are required. The results are shown on cross-section paper in the form of a curve whose magnification is 165 times.

Formula and Tables

The formula for computing the expansion of a material in millimeters per meter is as follows:

$$Xt = \frac{10\ Lt}{V} + Xqt$$

where

Xt = the expansion of a rod in millimeters per meter at the temperature t.

Lt = height of curve from horizontal base line at the temperature t. This is read directly from the plot made by the apparatus.

V = the magnification of the apparatus, *i. e.*, 165.

Xqt = the expansion of the quartz glass rod in millimeters per meter at the temperature t. (See table below.)

	Platinum	Pure iron	Constantan	Quartz glass
25– 100° Cels.	0.678	0.99	1.14	0.041
25– 200° Cels.	1.61	2.22	2.74	0.107
25– 300° Cels.	2.56	3.66	4.43	0.178
25– 400° Cels.	3.54	5.20	6.19	0.244
25– 500° Cels.	4.55	6.85	8.03	0.296
25– 600° Cels.	5.58	8.61	....	0.350
25– 700° Cels.	6.64	....	....	0.390
25– 800° Cels.	7.72	....	....	0.440
25– 900° Cels.	8.82	....	....	0.490
25–1000° Cels.	9.97	....	....	0.530

CHARLES ENGELHARD, INC.
30 CHURCH ST.
NEW YORK CITY

NOTES FROM THE U. S. BUREAU OF STANDARDS

Trial Run of New Cupola Furnace

As mentioned a short time ago, the metallurgical division of the Bureau has recently installed a small cupola furnace for melting cast iron, which will be of great value in connection with its research work on ferrous metals. A trial "run" of this equipment was made during the past month. It was found possible to melt the cast iron ready for pouring within four hours after starting the fire. Three hundred pounds of iron have been melted and poured into test bars and pigs. The character of the iron has not yet been determined, but so far as the operation and behavior of the furnace are concerned, the trial run was a pronounced success.

Cast Iron for Enameling Purposes

In connection with the Bureau's investigation of the enameling of cast iron, several typical castings have been received and have been coated with representative enamels. This work is still in progress, and all the castings will be examined for blistering. Microphotographs will be made of the surfaces in order to detect any changes produced by the enameling operation. It is hoped that the cause of blistering of these castings will be discovered, and means developed to control and if possible eliminate it.

Effect of Sea Water on Glass

Some work was carried out during the past month on the effect of sea water on various types of glass, to determine the best kind to use for the lenses of signal lights on shipboard. From the data which the Bureau has secured, the damage which these lenses often suffer appears to be caused by the evaporation of sea spray, which leaves a deposit of salt on the surface of the lens. This eventually etches the glass. Three types of glass, boro-silicate, lead glass, and ordinary soda-lime glass, have thus far been investigated. Under the conditions of the test, lead glass etched considerably, while the other two did not.

New Micrometer for Accurate Measurements

A micrometer of extraordinary accuracy has been constructed by the Bureau of Standards for determining the diameter of some 12-inch porcelain cylinders to be used in electrical measurements. Measurements made with the new instrument are independent of the observer and have an accuracy of 0.0001 of an inch. In order to obtain this degree of accuracy, it is necessary to operate the micrometer from a distance and to take readings from it through a telescope so that the heat of the observer's body will not warp the thick iron ring enough to cause an error. Both the instrument and the cylinder which it is employed to measure must be kept in a constant-temperature box during the measurement. The micrometer consists of a cast iron ring large enough to pass easily over the 12-inch cylinders. On opposite sides are the micrometer screw and the contact pin, while at right angles to these are adjustable lugs for centering the device on the cylinder. The micrometer screw is driven by a tiny electric motor and the ring with its attachment, including the motor, is suspended by three light rods and can move freely for a short distance.

In making a measurement the micrometer screw is revolved by the motor through a train of gears, the motion of the screw pushes the cylinder against the contact pin and when this contact is made, the motor circuit is broken thus stopping the screw. The cylinders which are to be measured will be wound with wire on a precision lathe and will form inductance coils of very accurate construction, the inductance of which can be calculated from the dimensions. They will be used for research work in a program

for standardizing all of the electrical units in terms of the fundamental standards of length, mass, and time.

Study of Architectural Properties of Terra Cotta

During the past month 110 balusters and 68 coping blocks, fired in commercial kilns, were forwarded to the Bureau for test and have been set in mortar and exposed for weathering. A duplicate set is being saturated with paraffine and will also be subjected to the weathering tests. Absorption is being determined on balusters, and tests for this property, as well as for transverse strength, have been made on specially prepared bars representing five bodies used in the manufacture of terra cotta. The data thus secured will be correlated with the heat treatment which the respective pieces receive in firing.

Investigation of Potters' Flint Including the Effect of Kryptocrystalline Flint in Pottery Bodies

Eight sanitary ware bodies made with flint under investigation by the Bureau have been fired and tested for transverse strength, porosity, and resistance to quenching. The porosity and strength of the bars varied considerably, indicating the need of a longer soaking period in finishing these burns, and for this reason the work will be repeated.

The strengths of the fired bodies did not show a regular variation according to type of flint used, such as was found in the case of vitreous china. The work, therefore, needs to be checked, and additional samples of flint have been requested from the producers.

In connection with the porosity determination, various methods and periods of soaking have been tried in order to show their relation to the method used in this investigation. A few experiments on drying the saturated pieces have also been carried out. Quenching tests made from 200°C to water at 30°C confirm previous indications that bodies made with the kryptocrystalline type of flint are more resistant to failure than those made with sand or rock quartz.

Standard Specifications for Whiteware Pottery

A committee of the Vitrified Chinaware Manufacturers met with the Committee on Chinaware and Glassware of the Federal Specifications Board on July 10 and three sets of chinaware were agreed upon, *viz:* (1) $^1/_2$ thick vitrified chinaware for enlisted men's dining service as used by the Army, Navy and Marine Corps; (2) vitrified hotel chinaware for all government dining service and hospital service, where desired; (3) $^1/_4$ thick vitrified chinaware for hospital service. Drawings of the different articles are now being made so that each purchasing department and manufacturer can be supplied with a set of blueprints.

Physical Properties of Clay Bodies as Affected by Drying Treatment

Tests have been made upon the physical properties of various clays and body compositions to determine the effect of drying treatment. Some of this work is being carried out in coöperation with the investigation of the effect of various potters' flint in semi-porcelain bodies. In this way drying effects are being traced from the plastic to the burned state, and the effect upon the drying behavior of variation in the body composition is noted.

Observations are being made to determine the effect of gravity upon the uniformity of drying and shrinkage in large commercial pieces. It is expected that it will be possible to establish a set of standard laboratory drying tests, similar to the firing tests now used,

and from these the ideal drying treatment and resulting effects may be reported for any clay or body which may be submitted to the Bureau for examination.

Plasticities of Clay

Work is in progress on the development of a penetration type of plastometer to be substituted for the capillary tube plastometer. The latter form is not applicable to very stiff paste or bodies, such as those used by potters in the molding of forms, but is used in the study of clay slips employed in the casting process, but not the study of the molding range.

With the capillary tube plastometer, the shearing stress is varied by changing the total pressure acting on the material, while in the penetration type, the shearing stress is varied by changing the pressure of the penetration rod.

Dictionary of Specifications

Work has been started at the Bureau of Standards on the compilation of material for a dictionary or handbook of specifications for supplies purchased by Federal, State and Municipal governments and public institutions. This work grew out of a meeting held in May, 1923, of State Purchasing Agents from all over the country, and at which the coöperation of the various states was assured in this matter.

On July 11, a conference was held of various national organizations interested in the preparation and unification of purchase specifications and in their use from the point of view of both the producer and the consumer. This conference was called for the purpose of organizing an advisory committee to coöperate with the Department of Commerce and the National Conference of State Purchasing Agents in the work of formulating purchase standards, specifications, and tests. Although no meeting of this advisory committee has yet been held, the various organizations represented are coöperating actively in the actual work of compiling the material for the dictionary, and a great deal of information has been supplied.

Correspondence conducted with the officers of trade associations and the purchasing agents of a large number of municipalities and public institutions has established the fact that all the individuals and groups for which the dictionary of specifications is being prepared will welcome its appearance enthusiastically and coöperate actively in the preparation.

A collection is now being made of all available specifications prepared by the various departments and independent establishments of the Federal government and those used by State and Municipal governments, public institutions, and the important national trade associations, and technical societies. These specifications are being thoroughly card-indexed and classified. Care is being taken to pick out those specifications which are most urgently needed, and due consideration is being given to the attitude of purchasers and consumers toward the existing and the proposed specifications.

GOVERNMENT EXPERTS PRODUCE LARGEST LENSES EVER MADE FROM AMERICAN OPTICAL GLASS[1]

Department of Commerce Describes Accomplishment as "Marked Advance" in American Industry

The largest lenses so far made from American optical glass have just been completed at the U. S. Bureau of Standards, it was announced today at the Department of Commerce.

[1] Department of Commerce, Washington, D. C.

The difficulties of securing a good enough piece of glass increases greatly as the size increases, the government experts say, and the production of 12-inch lenses having a combined focal length of 12 feet 8 inches represents a marked advance over what was possible in America a few years ago. It is considered only a question of time, however, before much larger lenses can be made at the Bureau of Standards, according to experts.

In discussing the significance of the accomplishment, Dr. G. K. Burgess, Director of the Bureau of Standards, stated that until the beginning of the war in 1914 the art of making optical glass was unknown in this country, all glass used here being imported from Europe. When the European supply was cut off the Bureau of Standards began research looking towards the development of the industry in America. By the end of the war the plant built at the Bureau of Standards in Washington was able to turn out large quantities of excellent glass and several of the large optical manufacturers had built plants of their own. But no lenses much over five inches could then be made here, for the production of large lenses is a branch by itself requiring special care.

Optical glass is made in pots holding a thousand pounds each, and if the pot is cooled to room temperature within a few days the glass will break into many small pieces. These cannot be welded together, so the lens cannot be larger than the largest piece. If several weeks are taken for the cooling of the pot the glass may come out in one big piece, but great care is required in the making in order that this large piece may be sufficiently free from defects to be used as a single lens. Difficulties are encountered in the annealing of such pieces.

Final Polishing May Take Weeks

The lens is molded to nearly the proper form and is ground to the correct shape as exactly as is possible with the best of measuring instruments. But the final finishing must be done by hand and all errors of as much as a millionth of an inch corrected. The surface is carefully polished with rouge, a little here and a little there, until tests show it to be correct.

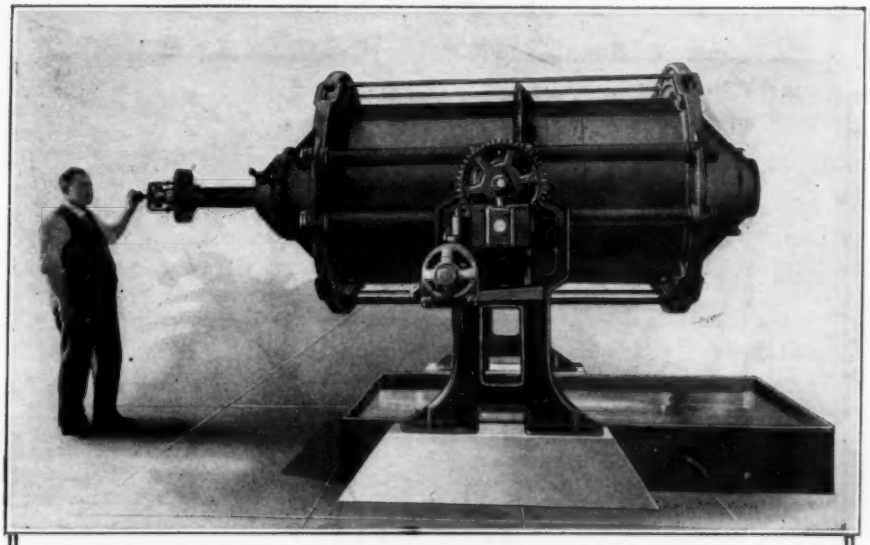
The test used for showing errors in the lens consists, in effect, of forming an artificial star with the lens and then viewing it through the lens. A tiny pinhole in the metal chimney of an oil lamp is placed at the focus of the lens, and a mirror behind the lens reflects the light from this artificial star back through the lens again to an eyepiece placed beside the lamp. The light thus passes through the lens twice and the effect of defects is thereby exaggerated. A patient study of the lens then permits them to be located and corrected. As there were four surfaces to this pair of lenses the magnitude of the task can well be imagined. The work was done by Mr. John Clacey of the Bureau staff, and occupied a large part of his time from the first of April to the middle of July.

These lenses form what is known as an achromatic combination. One is of crown glass, the other of flint glass, and the combination is so designed as to bring light of all colors to a focus at the same point, whereas with a single lens the focus is different for different colors. It will be used by the Bureau of Standards for various kinds of research in optics and possibly for making astronomical observations. It will be especially valuable in optical problems which require the use of a beam of parallel light.

CALENDAR OF CONVENTIONS[1]

Organization	Date	Place
AMERICAN CERAMIC SOCIETY (Annual Meeting)	Feb. 4–8, 1924	Atlantic City
American Concrete Institute	Feb. 25–28, 1924	Chicago
American Face Brick Assn.	Dec. 4–6, 1923	French Lick, Springs Ind.
American Face Brick Assn. (Southern Group)	Nov., 1923	West Baden, Ind.
American Institute of Electrical Engineers	Feb. 4–7, 1924	Philadelphia
American Malleable Castings Assn.	Jan., 1924	Cleveland, Ohio (?)
American Road Builders' Assn.	Jan. 14–18, 1924	Chicago
American Zinc Institute	May, 1924	St. Louis, Mo.
Assn. of Scientific Apparatus Makers of U. S. A.	April 18, 1924	Washington, D. C.
Common Brick Mfrs. Assn. of America	Feb. 11, 1924	Los Angeles, Calif.
Gas Products Assn.	Jan., 1924	Chicago
Hollow Bldg. Tile Assn.	Jan., 1924	Chicago (?)
Institute of Metals, Div. of American Institute of Mining and Metallurgical Engineers	Feb., 1924	New York City
Natl. Assn. Brass Mfrs.	Dec., 1923	New York City
Natl. Assn. of Stove Mfrs.	May 7–8, 1924	New York, Hotel Astor
Natl. Bottle Mfrs. Assn.	April 27, 1924	Atlantic City
Natl. Brick Mfrs. Assn.	Jan. 28–Feb. 2, 1924	Cincinnati, Ohio
Natl. Builders Supply Assn, Inc.	Feb., 1924	Chicago (?)
Natl. Electric Light Assn.	May or June, 1924	
Natl. Glass Distributors Assn.	Dec. 4–5, 1923	Pittsburgh, Pa.
Natl. Paving Brick Mfrs. Assn.	Dec., 1923	
Penna. Gas Assn.	April, 1924	Atlantic City
Portland Cement Assn.	Nov. 19–21, 1923	New York City
Society of Promotion Engineering Education	July, 1924	Boulder, Colo.
Stoker Mfrs. Assn.	April or May, 1924	(?)
U. S. Potters Assn.	Dec., 1923	Washington, D. C.
Western Society of Engineers	June 4, 1924	Chicago

[1] Further information may be secured through the Chamber of Commerce of U. S., Washington, and World's Convention Dates, New York, N. Y



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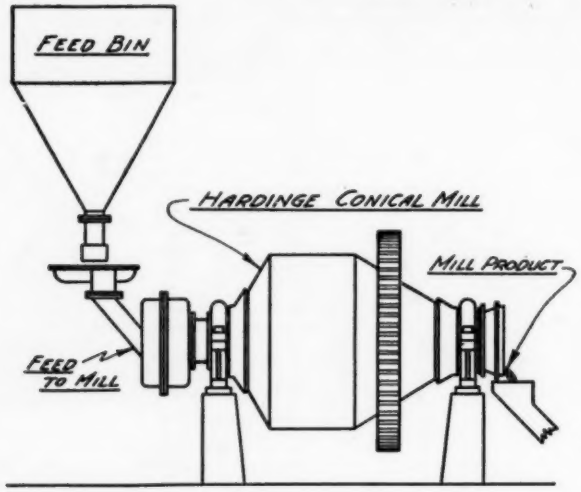

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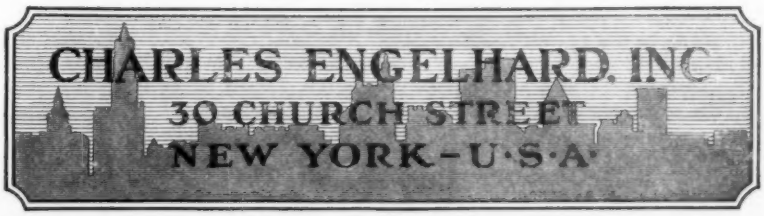

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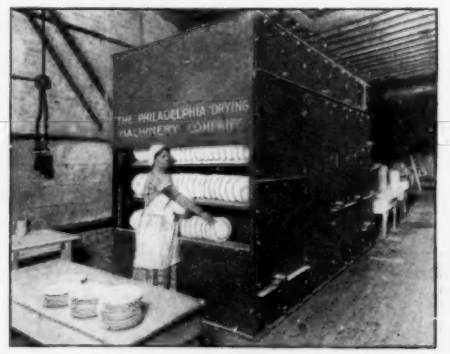

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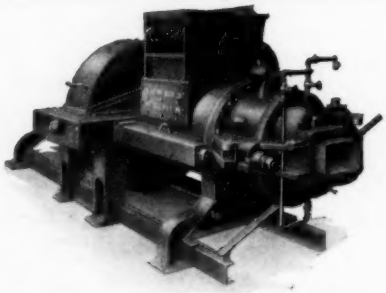

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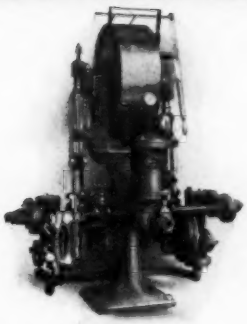

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